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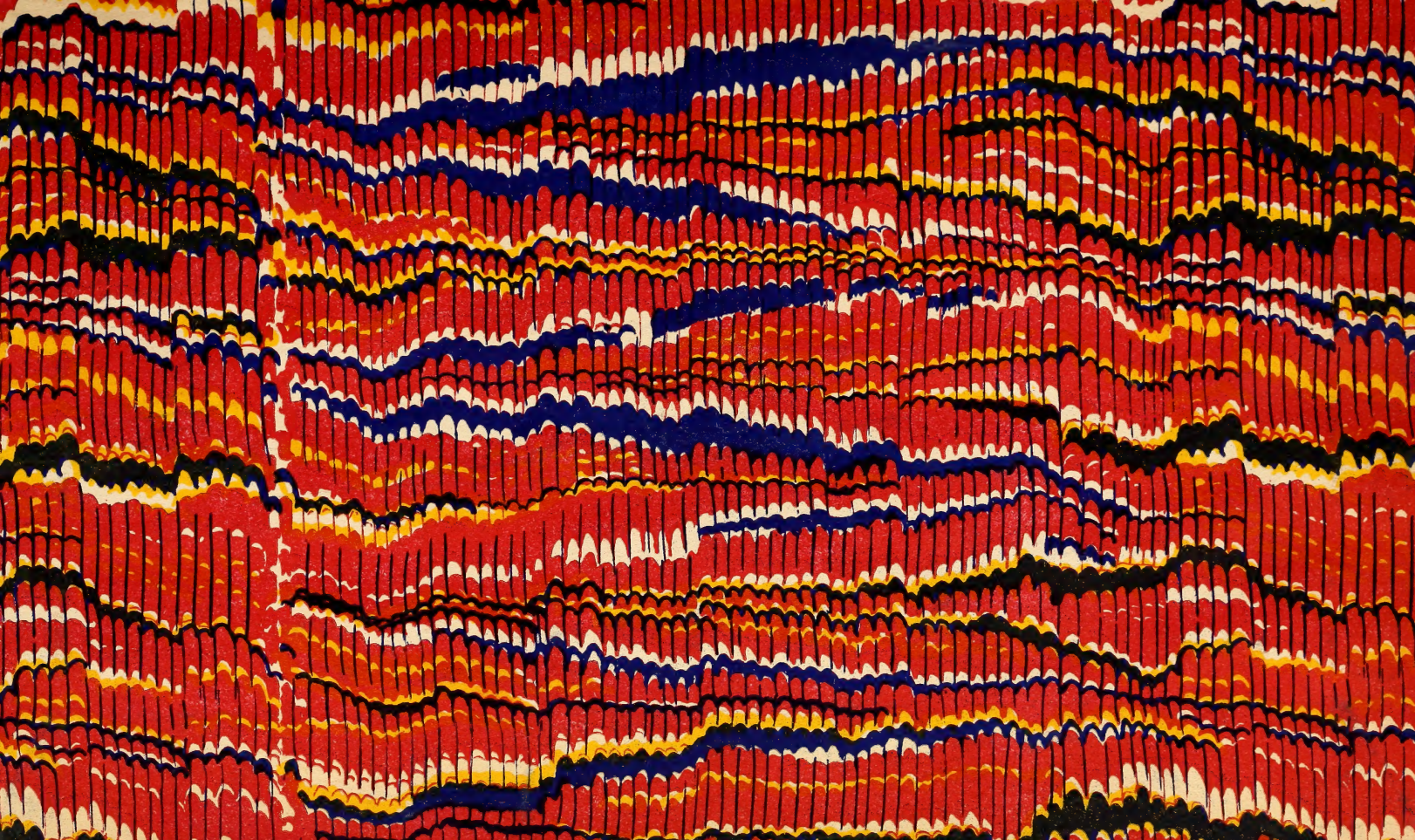

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REPORT OF THE SECRETARY OF AGRICULTURE ~ 1929

REPORT

OF THE

SECRETARY OF AGRICULTURE

1929

UNITED STATES
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REPORT OF THE SECRETARY OF AGRICULTURE

WASHINGTON, *D. C., November 15, 1929.*

To the PRESIDENT:

THE YEAR IN AGRICULTURE

Widespread drought during the growing season of 1929 dried up pastures and reduced crop yields below those of any recent year. The losses in production, however, were so evenly distributed for the country as a whole that no large area had either very bountiful or very short crops. Moreover, from the standpoint of the producers, reduced yields seemed likely to be more than offset by price advances. It is probable that the total income from agricultural production for the 1929–30 crop year will equal, if it does not exceed, that of the 1928–29 season.

Cool spring weather, with heavy rains, delayed planting in many sections of the West and Northwest. Planting was exceptionally backward in the States from Ohio to Missouri, where some corn was not put in the ground until July. Rainfall was light and spotty during the early summer, especially in the northern half of the country. A general drought developed during August, except in the far Southwest. Conditions improved somewhat during September, and some crops turned out rather better than had been expected.

Growers planted a total acreage about equal to that of 1928. Yields were disappointing in practically all crops, except irrigated crops and some varieties of hay. The hay crops that turned out well made heavy growth before the drought became severe. All crops combined gave a yield per acre 7.4 per cent below that of 1928 and 4.1 per cent below the average for the preceding 10 years. Lower than average yields were experienced in 29 States. The western Great Plains suffered most from the drought. Yields were reduced along the Atlantic coast from Massachusetts to North Carolina and in all the North Central States except Wisconsin. California and Washington suffered from drought during the winter of 1928–29, and California fruits were injured by a severe freeze in April. The late spring reduced yields somewhat in the other fruit-producing areas, except the apple-producing sections of Virginia and West Virginia.

Reduced Yields in Corn

Corn production was 2,528,000,000 bushels, or 308,000,000 bushels less than in 1928. With the exception of the crop of 1924, this year's corn crop is the smallest since 1918. The acreage in corn was smaller than in 1928; but reduced yields were the principal cause of the

reduced production. New England, New York, and the Southern States east of the Mississippi River produced more corn than in 1928. Corn production in the northern part of the Corn Belt was not materially below that of the previous year. The yields were reduced most in the area just north of the Ohio River, in Missouri, in Kansas, and in the far Southwest. The production of grain sorghums, which supplement corn for feed in the southwestern area, totaled only 93,000,000 bushels, as compared with 142,000,000 bushels in 1928 and an average of 128,000,000 bushels for the past five years.

Wheat production, winter and spring varieties combined, totaled about 792,000,000 bushels, as compared with 902,000,000 bushels in 1928. This output was between 4 and 5 per cent less than the annual average for the previous five years, though the harvested acreage was about 9 per cent larger. The greatest decline was in spring wheat, the production of which was only 224,000,000 bushels, as compared with 324,000,000 bushels in 1928. Durum wheat production was only 53,000,000 bushels, against 93,000,000 bushels in the previous year. The acreage in durum wheat was only 80 per cent of the 1928 acreage. Production of winter wheat was about 10,000,000 bushels less than in 1928, though the acreage harvested was 10 per cent greater. The hard winter wheat crop in the western Great Plains was reduced materially. Soft winter wheat production, however, was somewhat above the unusually small crop of 1928 and nearly equal to the average for the previous five years.

Oats Production Below 5-Year Average

Oats production was about 120,000,000 bushels less than the average for the preceding five years, and barley production was 104,000,000 bushels above that average. Output of both crops was smaller than in 1928. Their production was fairly well distributed over the country. Flax production was only 16,600,000 bushels, as compared with 18,700,000 bushels in 1928 and an average of 23,200,000 bushels for the preceding five years. Acreage seeded to flax was 17 per cent greater than in 1928, but yields were greatly reduced by frosts early in the year and by drought early in the summer. The yield per acre averaged only 5.4 bushels, the lowest since the unusually dry year, 1919.

Cotton production, according to the October estimate, was 14,915,000 bales, as compared with 14,478,000 bales ginned last year. This output was grown on an acreage only slightly below the record acreage of 1926. Yields, however, were greatly reduced by drought in Oklahoma and in much of Texas. The eastern part of the Cotton Belt had about an average yield. In that section heavy weevil infestation in the fall of 1928 and a mild winter in 1928–29 threatened heavy losses from the boll weevil. The dry summer, however, helped to control the insect. Potato production was about 345,000,000 bushels, as compared with the excessive production of 454,000,000 bushels in 1928. Drought and excessive heat in many States were unfavorable to the crop. In the Northern States rains in early September were so closely followed by frosts that the crop could not recover. Yields of potatoes were light everywhere, except in northern New England and a few of the Western States. The acreage planted to potatoes was very close to the average for recent

years. It seems probable that the reduced potato crop will bring the farmers considerably more than last year's heavy crop brought them. Should present prices prevail for the marketing season, the income from potatoes will be approximately 75 per cent greater than in 1928.

Tobacco production was above that of 1928 and above the average for the preceding five years. This crop was planted on an acreage nearly 6 per cent greater than that in the previous year, and yields were about the same. Moreover, the quality of the crop is better, while prices for most kinds are at least equal to those of last year. Hay production was rather unevenly distributed, though the yield for the country as a whole was about the average, and acreage also was about the average. The crop was unusually good in the North Central States east of the Mississippi River and also west into Missouri, Iowa, and most of Nebraska. West of these States in a semicircular area extending from Arkansas through Oklahoma and Texas and parts of Kansas and Colorado into the Dakotas, hay production was sharply reduced. It was light also in most of the Northwest. Fruit production was generally low. The apple crop was reduced in some of the Northern States by dry weather. The Southern peach crop suffered from unfavorable weather at blooming time and from rain during the harvesting period. Citrus fruits in Florida suffered from drought in the winter of 1928–29 and bloomed only lightly in the spring. As already noted, deciduous fruits in California were damaged by a freeze in April. Yields of tree and vine fruits averaged about one-fourth less than in 1928.

WHEAT

Though this season's wheat crop is considerably smaller than that of 1928, it may return the growers a larger income. Wheat prices have been substantially higher so far this season than they were during the corresponding period of the 1928–29 season. A reduction in our wheat output is offset by an increase in the carry-over from the previous season. Stocks on July 1 totaled 245,000,000 bushels compared with 128,000,000 bushels on the same date in 1928. Income from wheat depends, however, on the world wheat situation as well as on the situation in the United States. The world's production of wheat outside Russia and China in 1929, according to the reports now available, is about 3,400,000,000 bushels, or 500,000,000 bushels less than the record crop of 1928. As the carry-over was larger than that of the previous crop year, the total world supply for 1929–30 is only about 360,000,000 bushels less than the supply available in 1928–29. Nevertheless, the indicated reduction has raised the world price level. It seems probable that the average price for the year to United States growers will be better than the average for 1927–28.

Returns from wheat farming in recent years illustrate the familiar fact that it is not always the largest crop that brings the greatest cash return. Our wheat production in 1927 was 878,000,000 bushels. The 1928 crop was 902,000,000 bushels. Wheat marketed from the 1927 United States crop was sold at an average price at the farm of $1.19 a bushel, and brought the farmers a cash income of $862,000,000. Wheat marketed from the 1928 crop was sold at an average

price of only $1 a bushel, and brought in a cash income of only $753,000,000. The difference in the returns from wheat in these two seasons was largely the result of a great increase in the world crop. World production outside Russia and China in 1928 was about 3,900,000,000 bushels, or 250,000,000 bushels more than in 1927.

Producers' Intentions to Plant

Winter wheat producers' plans for the 1930 crop, as expressed in intentions to plant reports, contemplated a wheat acreage 1.2 per cent greater than that seeded in the fall of 1928. Such an acreage, with average abandonment and average yields, would increase our exportable surplus of the 1930 crop and increase the dependence of the producers on the foreign market. The world market for wheat of the 1930 crop probably will be no better and may not be as good as the world market for the present season. Keen foreign competition is in prospect. Russia may again be a factor in the world's wheat market in a few years, and Canada, Australia, and Argentina are vigorous competitors of the United States. The principal wheat-exporting countries show a general tendency to expand their wheat acreage. It seems doubtful, in short, if the supplies of wheat in the world's markets during the next few years will average much under the levels for the past six years, unless an unusual combination of circumstances should give a series of low yields.

COTTON

In the 1928–29 season cotton producers received a lower price per pound, but for a larger crop they received about the same amount of cash as in the previous season. On an increased acreage they harvested 14,478,000 bales. Yields for the Cotton Belt as a whole were 3 pounds per acre below the 10-year average. In the Atlantic Coast States yields were still lower. This region had disastrous storms shortly after picking began. In many counties of the coastal plain the damage was so great that seed loans from the Federal Government were necessary for the planting of the new crop. Although production in 1928 was 1,500,000 bales greater than in 1927, the world carry-over of American cotton was greatly reduced. In consequence the total supply available for the season was only about 19,600,000 bales, as compared with 20,800,000 bales for 1927–28.

The domestic consumption of cotton was low at the beginning of the 1928–29 season but soon increased. The total for the season amounted to 7,091,000 bales, or 257,000 bales more than in the 1927–28 season. The opposite situation prevailed in the export market. Exports were large early in the season, but declined rapidly after December because of a less active European demand. As a result, despite a material reduction in foreign stocks at the beginning of the season, and lower cotton prices, Europe took practically no more American cotton than in the 1927–28 season. Japan, however, took nearly one-half million bales more. The world's consumption of American cotton in the 1928–29 season amounted to about 15,076,000 bales. The world's carry-over of American cotton at the end of the season was about 4,500,000 bales.

The 1928–29 cotton marketing season was characterized by the most stable prices which have existed in any year since the World War. The total range in the spot markets was only about 3½ cents a pound. Prices were mostly within a range of 1½ cents. For the season August 1, 1928, to July 31, 1929, Middling cotton at the 10 spot markets averaged 18.67 cents a pound, or about 1 cent a pound less than the price for the previous year. At the beginning of the 1929–30 season the world's supply of American cotton was approximately the same as at the beginning of the previous season. An increase of slightly more than 400,000 bales in the production was offset by a decrease of about 600,000 bales in the carry-over. This left a total supply for the season of about 19,400,000 bales, compared with 19,600,000 bales in the 1928–29 season. For the first two months of the current season cotton prices averaged slightly above the average for the corresponding two months of the previous season but slightly below the average for the entire 1928–29 season.

Elements of Quality in Cotton

It is important that the elements of quality in cotton be better recognized. This is a complex problem. Cotton is not a homogeneous thing but a mass of individual fibers. The department is studying the relationships that exist between the properties of the fibers and the qualities of the products into which they enter. Studies are also under way, in cooperation with the States, as to the relationship between prices paid to growers and the quality of the cotton sold. A buying system by which cotton of all qualities is bought at an average price penalizes the producer of better-quality cotton and gives an undeserved premium to the producer of inferior cotton. Study of these practices should suggest means of improvement.

In the 1928–29 season the department for the first time obtained and published information as to the number of bales of cotton of each grade and staple produced, carried over, and consumed in the United States. The production of cotton having a staple length of seven-eighths of an inch and under, and of cotton 1⅛ inches and over, was apparently ample, but cotton of 1 inch and $1\frac{1}{32}$ inches was relatively scarce. Our production would apparently better fit the demand in this country if less very short-staple cotton and more cotton in the range from 1 inch to $1\frac{1}{16}$ inches were grown.

Selection of cotton for manufacturing becomes more discriminating each year. If American growers are to improve or even to hold their present position in the world's market, more thought must be given to producing the better qualities of cotton that are most in demand. Information now gathered permits estimates of the quality of production to be made for the United States as a whole and for individual States, but not for smaller areas. It is desirable to intensify the work, so that grade and staple reports may be made for counties. Such reports would mean much to individual growers, and would facilitate improvement through community action. They would particularly emphasize the advantages of the single-variety community plan, which may hold more promise of improvement in the production of good-quality cotton than any other single action.

Moreover, the single-variety community plan offers the best foundation for community organization in merchandising.

LIVESTOCK

Further improvement was made by the livestock industry in 1929, though favorable trends were not as sharply defined as in 1928. Certain branches of the industry showed losses, but gross returns to livestock producers in the first eight months of the year were approximately $93,000,000 more than in the corresponding period of 1928. Figures showing net returns are not available, but undoubtedly the current year has been profitable for the livestock industry on the whole. Gain in gross income was effected despite a decrease of 1,187,000 head of meat animals slaughtered under Federal inspection in the first eight months of the year as compared with the number slaughtered in the corresponding period of 1928. The increased return from a reduced volume of sales was partly the result of higher average prices and partly of a higher average weight in the animals slaughtered.

Though cattlemen generally have prospered this year, some who fed cattle during the fall and winter of 1928 suffered losses. In the first three months of 1929 a slump occurred in fed-cattle prices. This reacted unfavorably on the demand for feeder cattle during the summer and the early fall. As a result, feeder-cattle prices declined sharply. On September 15 the prices of such cattle at Chicago were nearly $2 a hundred pounds below the prices of the year before. However, the average price of slaughter cattle in the first eight months of 1929 was 23 cents a hundred pounds higher than in the corresponding period of 1928 and $2.54 a hundred pounds higher than in the corresponding period of 1927.

Though 2.5 per cent fewer cattle were slaughtered during the first eight months of 1929 than in the first eight months of 1928, the gross return to producers was $3,700,000 more, due to higher prices and increased average weights. Returns from calf slaughter have increased from the same causes. Indications are that the total marketings of cattle and calves for the full year 1929 will be somewhat less than in 1928 and will make the smallest total since 1921. Yet the prospect is for an increase in gross returns. During the last year high prices for cattle have attracted larger shipments of dried beef from Argentina and of fresh beef from New Zealand to this country.

Hog Slaughter Smaller

Hog slaughter likewise was smaller during the first eight months of 1929 than in the corresponding period of 1928. The decrease was about 4 per cent. Average weights of the animals slaughtered, however, were considerably higher, and average prices for the period showed an advance of $1.24 a hundred pounds. Hence producers received nearly $81,250,000 more than in 1928. In general the first three-fourths of the year was marked by constancy in supplies and prices. Toward fall, receipts of hogs at public stockyards increased materially, and prices declined. Average prices at Chicago in the middle of September were about $1.70 a hundred pounds lower than

at the July peak, and nearly $3 a hundred pounds lower than in September, 1928.

The foreign demand for pork products has been strong in the last few months because of reduced production in several countries of northern Europe. These countries now show a tendency to increase their hog production. The pork-production cycle of northern Europe tends to coincide with that of the United States. It is therefore probable that American pork in northern European markets will meet increased competition within the next year and a half. Demand for hog products continues strong in the United States as well as in foreign countries. In the United States the strong demand is partly the result of the prevailing high prices for other meats and partly of favorable general business conditions. The demand for lard, however, has been adversely affected of late by the low prices of competing vegetable oils. The outlook for the coming winter and spring is for higher average hog prices than those of the preceding winter and spring. But if producers react as they have done formerly to similar price situations, farrowings next spring will increase. This, together with prospective European increases, will tend to start prices on the downward swing of the cycle during the latter part of 1930.

Record Returns from Sheep

Sheep producers, unlike the producers of cattle and swine, marketed an increased number of animals in the first eight months of 1929, as compared with the number marketed during the corresponding period of the previous year. In that period receipts of sheep and lambs at public markets were 6 per cent greater than in the first eight months of 1928. Federally inspected slaughter increased about 6½ per cent. This increase was happily accompanied by an increase in the gross money return to producers. It is estimated that this increase was nearly $7,000,000, or 7 per cent over the return during the corresponding period of 1928. A high level of beef prices helped to increase the demand for lamb and mutton. Also, the producers' campaign for increased lamb and mutton consumption was apparently effective in increasing the demand for lamb and mutton.

On the whole, the lamb market was steadier than it had been for several years, and marketings and prices followed normal seasonal trends more closely than was the case with either cattle or hogs. However, the increase in lamb and mutton prices which made possible the improvement in gross returns occurred during the first four months of the year. When the new-crop lambs came to market, the earlier price levels could not be maintained. Market supplies of sheep and lambs from April to August were 9 per cent greater than in the corresponding period of 1928, and 33 per cent greater than in the corresponding period of 1924. They constituted a record run for the period. As a result, the average price of sheep and lambs slaughtered in August was $1.15 a hundred pounds under the average price in August, 1928, which decrease was offset by the increased number of sheep and lambs that producers had to sell. Probably the gross returns of the sheep industry for 1929 will exceed those for any previous year in its history.

Wool producers have felt the effect of increased foreign competition recently. In June, 1929, the average price received for wool by the farmers of the United States was 30.2 cents a pound, as compared with 38.7 cents a pound in June, 1928. This decline may be attributed largely to increased wool production in Australia. Many other countries have expanded their sheep and wool production in recent years under the stimulus of satisfactory wool prices. The world wool clip of the past season was probably 5 or 6 per cent greater than that of the previous season. In the United States the number of sheep continued to increase. Production of wool (fleece) this year increased about 1 per cent over the production in 1928, and was estimated at about 302,000,000 pounds; it was 36 per cent greater than the production in 1922. In 10 countries which ordinarily produce a little over two-thirds of the world's output of wool, production in 1928 was estimated at 2,530,000,000 pounds (in the grease), an increase of 6 per cent over the production in the same countries in 1927. Stocks of wool at the beginning of the season at the principal primary markets were considerably higher than at the beginning of the previous season. The number of sheep sheared in 1929 in important wool-producing countries was probably larger than in 1928.

DAIRYING

In general the position of the dairy industry has been favorable this year, though not as markedly so as it was in 1928. Prices of butter, cheese, and other dairy products have not averaged as high as they did last year, largely because dairy production increased generally during the spring and summer months. In the fall, however, dry pastures curtailed production. Consumption during the year held up fairly well as compared with consumption in recent years. In the last eight years, despite a generally upward trend in dairy production, our domestic consumption of dairy products has consistently exceeded our domestic production by about 1 per cent. There is reason to believe that this close adjustment will continue. The dairy industry is very stable. It is not showing any immediate prospect of a marked expansion. Continuance of the stability it has shown in recent years should help the dairy industry to continue as one of the most satisfactory branches of agriculture.

As already noted, our dairy production is slightly less than our consumption, and during the fiscal year 1928–29 our net imports of dairy products were valued at $19,854,000, as compared with $20,392,000 in the previous fiscal year. Our dairy imports, as is usually the case, consisted largely of European varieties of cheese, and of fresh milk and cream from Canada. Our exports of dairy products consisted chiefly of condensed, evaporated, and powdered milk. This country usually imports some butter during the winter and early spring. This period coincides with the peak of dairy production in New Zealand, from which country the bulk of our butter imports come.

It seems probable that foreign competition from this and other sources will increase. From January to August, 1929, foreign butter shipments to Great Britain and Germany, the principal deficit areas of Europe, exceeded those during the corresponding period of 1928 by some 5 per cent, and the corresponding 1928

volume was 10 per cent more than that of 1927. Butter prices in the first eight months of 1929 averaged 10 cents a pound lower in Copenhagen, the principal foreign market, than the prices of corresponding grades of butter in New York. Any further increase in foreign supplies of butter might cause prices in foreign markets to fall to a level that would place foreign butter producers in direct competition with those of the United States. It is worth noting that important technical improvements have recently taken place in the dairy industries of New Zealand and Australia, with very favorable results upon production.

FRUITS AND VEGETABLES

Expansion in the fruit and vegetable industry has been rapid since the war, as is shown by the fact that receipts of fruits and vegetables at 11 large cities have doubled in the last seven years. Increases have been particularly striking in the receipts of some of the annually planted crops, notably lettuce, green peas, snap beans, cauliflower, spinach, carrots, and cantaloupes. Competition resulting from an increased supply of fresh products all the year round is felt very keenly by the canning industry. Accordingly, canners are energetically striving to improve the quality of their output. To that end they are developing methods of buying raw products from the farmers on a quality basis rather than at flat rates per ton or bushel. This method promises increased benefit to both producer and consumer.

Attention has been given by the department to specifications of grades for fruits and vegetables for canning, since the canner's requirements differ from those of the individual consumer. Inspection and grading of fresh tomatoes have been done experimentally at a number of factories, with results that seem to justify further effort. Inspection and grading accompanied by the payment of a premium for deliveries containing a high percentage of No. 1 fruit mean increased returns for the careful grower, and a more profitable output for the canner.

A study of car loadings of fresh products for the general market indicates a marked concentration of surplus production. Carload shipments of head lettuce, celery, cantaloupes, and bunched vegetables originate chiefly in a few well-defined and rather limited areas. Railroad shipments alone, however, no longer give a correct picture of the trade in fresh fruits and vegetables. It is necessary also to consider highway transport. Improved highways and motor transportation are profoundly changing this situation. Though the total volume of perishable farm products shipped by motor vehicles has not yet been measured, studies conducted by the department in certain typical markets and producing districts prove that in many cases the movement by motor far exceeds that by rail. In all producing districts within about 200 miles of large markets the transport of perishables over the highways is increasing rapidly.

Influence of Road Improvement

Road improvement is making nearly all of the farm land in the Eastern States potentially available for truck crops. Fruits and

vegetables may now be grown upon the land best adapted thereto, instead of being confined to land within a few miles of the city market. Thus more economical and more efficient production is insured in this region, and distant truck-growing areas will find it increasingly difficult to invade large eastern markets during the season of local production. Large car-lot shipments will therefore probably continue to be confined to regions that can market fresh products when such crops are not obtainable within possibly 200 miles of the larger consuming centers.

Motor transport affects the marketing of fruits and vegetables in other ways. Some truck operators are itinerant merchants who buy at the farm, for cash, products that formerly went to market for sale on commission. These distributors supply small stores, and sometimes homes, with fresh fruits and vegetables from nearby producing districts or from large distributing centers according to the season.

Irregularity of production continues to be the most disturbing influence in the fruit and vegetable industry. It is constantly threatened by an overproduction of tree fruits. Recent experience indicates that unsatisfactory prices must be expected whenever either citrus fruits or the more important deciduous fruits yield full crops throughout the principal areas of production. This year frosts in April did extensive damage, especially in California, and relatively high prices prevailed for all summer fruits. The demand for melons and other fruit substitutes was stimulated, and growers generally received better rewards than usual. Good returns thus obtained, however, are not necessarily evidence that fundamental conditions are satisfactory.

Speculative financing of annual truck-crop production by men who are primarily distributors continues to be a disturbing influence. Well-established growers may be financed year after year by responsible distributors with advantage to all concerned, if such distributors have wide market contacts. But the tying-up of large tonnages under crop-financing contracts by dealers whose outlets are limited is an unfortunate recent development, which results in unsatisfactory distribution. Often it causes a too rapid movement of ill-standardized products. The department can deal with this situation only by education. An experimental effort to solve the difficulty is in progress in the southeastern early-potato States, with Federal and State agencies and also growers and dealers cooperating.

Increased use of the inspection service of the department, in both domestic and export trade, has been made in the last year. Foreign buyers of tree fruits are more generally demanding Federal inspection. Information services conducted for the fruit and vegetable industries by the department are increasingly in demand, and are being extended. The produce agency act has been vigorously enforced.

POULTRY

Conditions in the poultry industry have been very favorable this year. Producers have received good prices for both poultry and eggs, and their costs of production have not been unusually high.

At present, stocks of eggs are relatively low and supplies of poultry, though probably larger than at this time last year, are not burdensome. Some further increase in poultry supplies is in prospect. The industry is undergoing rapid changes, however; and the penalty for inefficiency is quickly felt. Methods and equipment that were modern only a few years ago may now be almost obsolete. Specialized poultry farms are growing in importance, though farm flocks still produce the greater part of our poultry and egg crop. The trend is toward higher-quality production; and the producer who does not keep up with the times may find his poultry flock a liability rather than an asset.

Specialization is shown not only by an increase in the number and in the average size of the producing units, but also by an increase in the size of farm flocks in many sections, and by better care given to flocks. Turkey raising, after a long decline, shows vigorous new life, gained through the adoption of new rearing methods. In some sections turkey raising is very profitable.

Factors in Recent Development

The mammoth incubator, the commercial baby-chick hatchery, and the coal-stove or oil-stove brooder have been important factors in the recent development of the poultry industry. Producers using these devices can hatch and brood chicks in larger lots with less labor. Recent research has emphasized the necessity of vitamins in the poultry diet and shown how to supply them. New methods make it possible to keep hens producing well in large flocks under relatively close confinement. Electric lights prolong the feeding time in winter, and thus facilitate increased egg production. Methods have been developed by which chicks can be reared to 10 or 12 weeks of age and even longer in batteries of coops under the most confined conditions and with a minimum of labor. In this way the production of out-of-season broilers is simplified and an additional source of income afforded to many specialized poultry enterprises.

But these developments have complicated certain phases of the industry. Large hatcheries utilize the hatching eggs of a group of breeders, while the chicks produced are sold mainly to a different group. It is necessary to safeguard the quality of the poultry stock so handled. Moreover, the use of large incubators increases the risk of spreading disease. Flock and hatchery accreditation has been started in a number of different States to insure better and healthier stock. Considerable differences prevail, however, both in methods and in nomenclature, and some uniform plan is desirable to eliminate the resulting confusion. Changes are in evidence also in the packing and distribution of poultry and eggs. Competition is causing the consolidation of packing and distributing agencies. Cooperative marketing has been a factor in developing this competition. Competition also causes poultry and egg-packing agencies, both private and cooperative, to furnish service in an increasing degree to patrons or members. The demand for finer and better standardized products spreads the practice of buying eggs on a graded basis, to the great advantage of producers.

AGRICULTURAL CONDITIONS IMPROVING

Agricultural conditions in the United States continue gradually to improve. Farm incomes in the crop season 1928–29 averaged higher than those of any season since 1920–21 except 1925–26. The movement of population from the country to the town declined, and the rate of depreciation in farm-land values declined also. This is evidence of improvement in basic conditions. Much further improvement will be necessary before the situation can be considered satisfactory. Since the war agriculture has suffered grave disabilities which the farmers by their own efforts have not been able to remove. In consequence, they are still overburdened with debt. As of January 1, 1928, farm mortgage debt in the United States was estimated at $9,468,526,000, as compared with estimated totals of $9,360,620,000 as of January 1, 1925, and $7,857,700,000 as of January 1, 1920. On the other hand, the farm bankruptcy rate was considerably lower in 1928 than in any year since 1922.

The position of agriculture in general at the close of the crop season 1928–29 was better than at the close of the preceding year, and there are prospects of continued improvement. The crop season 1929–30 began with a rising farm-commodity price level, and with only moderate supplies of the principal products in prospect. These circumstances, joined to the expectation that benefit will accrue to agriculture from the operation of the Federal Farm Board under the new agricultural-marketing act, warrant confidence that better times are in store.

Aggregate gross income from agricultural production in the United States for the crop season 1928–29 is estimated to have been $12,527,000,000. This was about $225,000,000 more than the aggregate gross income of the preceding year. Cash income from the sale of farm products is estimated to have totaled $9,949,000,000, or an increase of $79,000,000 over the corresponding figure for 1927–28. Net income of the farmers did not increase proportionately because farm operating costs, taxes, and interest on debts advanced somewhat. The income available for living on the farm, including the value of the farm products used by farm families, was only about $16,000,000 greater than in the previous season. The return earned on the current valuation of agricultural property was about the same, namely 4.7 per cent, compared with 3.1 per cent in 1922–23 and 1.4 per cent in 1921–22.

Livestock Enterprises the Most Profitable

Higher prices for livestock and livestock products were the principal cause of the improvement in the season's agricultural income. Increased unit prices more than offset a reduction in the volume of cattle, hog, and lamb sales. Income from meat animals was $145,000,000 more than in 1927–28, and income from dairy and poultry products was more than $200,000,000 greater. Income from grains and fruits and vegetables, on the other hand, was smaller. Reduction in the income from wheat and from potatoes was particularly marked, the markets for these products being oversupplied. The outlook for the present season is in sharp contrast in some respects with the results of last year. This season a short world wheat crop has

raised the price of wheat, and a short potato crop in the United States promises increased returns from that crop. The expectation of an increased aggregate income for agriculture rests primarily on the improved position of grains and fruits and vegetables. Indications are that the income from livestock may be little or no greater than it was in 1928–29.

In August the prices received by farmers for their principal products averaged 143 per cent of the pre-war level, compared with 139 per cent in August, 1928. It seems probable that the average level of prices for the 1929–30 season will be fairly close to the August average. This average may be compared with the corresponding figure for 1921–22, when the average farm-commodity price level was only 119 per cent of the pre-war average, while the price level of the commodities usually bought by farmers was more than 150 per cent of the pre-war level. In the last few years the prices of the commodities usually bought by farmers have not advanced but have remained in the neighborhood of 156 per cent of the pre-war level. In other words, the exchange value, or the purchasing power of farm commodities, has improved. In the calendar year 1928, for example, the prices received by farmers per unit of their principal products would buy about 90 per cent as much as the corresponding prices of the pre-war period. This purchasing-power ratio was 15 per cent higher than the corresponding figure for 1921.

Meaning of the Purchasing-Power Index

Improvement in the purchasing power of farm commodities, however, is not necessarily synonymous with an improvement in the purchasing power of the farmer. Since the farmer's purchasing power depends on the quantity of the commodities he has to sell as well as on their relative unit price, the purchasing-power ratios here quoted must not be overestimated as an index of agricultural prosperity. They are valuable in comparing one year with another; but a true measure of agricultural conditions necessitates taking many other things into the reckoning. Final proof of agricultural improvement must rest, not on price comparisons alone, but on evidence that the margin between total costs of production and total prices received is increasing. Only when the farmer's net income increases more than the prices of the things he must buy does he obtain an increase in purchasing power. In the last few years a substantial gain of this character has actually taken place. But the crop year 1928–29 saw more improvement in the gross farm income and in the price situation than it saw in the net income of the farmers, because of increased costs, including higher taxes.

The fact should not be overlooked, however, that a diminution in net farm income which may be due to an increase in taxes does not necessarily mean an impairment of the rural standard of living in general. Funds raised by taxation are in the main expended for local purposes, such as schools and roads and other community facilities. With economical use of funds, this may add as much to the general standard of comfort in the community as would have been added had individual farmers spent the money themselves instead of paying it out in taxes.

Agricultural Property Valuations

In the last two seasons the current value of agricultural property has increased. Land values in the season 1928–29 declined slightly, but the value of personal property, including livestock on the farm, increased sufficiently to raise the estimated current value of agricultural real estate and personal property to $58,645,000,000. This was an increase for the year of nearly $400,000,000. In view of the drastic decline that took place in agricultural values in the early years of the depression period, this recovery seems very modest. That decline was due to financial deflation and to depreciation in the earning power of agriculture. While the recent gain seems small, it is encouraging. The advance has been largely due to a rise in the value of livestock on the farm, and an increase in livestock production may mean a lower valuation for this item. On the other hand, continued improvement in farm incomes should strengthen the upward trend by stimulating activity in farm real estate.

FARM-LAND VALUES

Farm-land values have developed encouraging tendencies. As is well known, the general movement has been downward since 1920. While it is not yet possible to record a uniform change from the general downward movement, the latest data available indicate that farm real estate values have been appreciably nearer stability during the last year and a half than at any time since the downward movement began.

A survey made by the department for the 12 months ended March 1, 1929, showed that for the country as a whole farm-land values declined by 1 per cent. This was the smallest loss in any year since the postwar depression began and was nominal compared with the declines of 1921, 1922, 1923, and 1924. State and regional averages as a rule showed few of the sharp declines frequently recorded in the years immediately preceding. In the North Central States, for example, the year's decreases did not exceed the national average of 1 per cent. Values in the Southern States likewise declined only slightly during the 12-month period in question. In the Mountain States and the Pacific Coast States values held up well toward the previous year's level, and in a few States, including Montana, Wyoming, Arizona, and New Mexico, a slight upward tendency was manifest.

Current changes in farm-realty values are of course largely an outgrowth of economic disturbances caused by the war. In the postwar "boom" farm real-estate values for the United States as a whole rose to a level averaging 70 per cent above the pre-war level. Then followed a drastic decline to a present level 16 per cent above the pre-war average. Thus for the country as a whole, up to March 1, 1929, more than three-fourths of the war-time gain over pre-war levels had been canceled. In some States the drop considerably exceeded the national average and carried average values to pre-war levels or below. These percentages, moreover, make no allowance for the changes in the value of the dollar. When allowance is made for the decline that has taken place in the purchasing power of the

dollar during the last 14 years, it appears that farm real-estate values for the United States as a whole on March 1, 1929, were 20 per cent lower than in March, 1914. In other words, an acre of land that in 1914 could have been exchanged for 100 commodity units would have brought only 80 such units in March last.

Forced Sales and Related Defaults

Forced sales and related defaults in connection with farm land decreased during the 12 months ended March 1, 1929. In that period the rate of forced sales and related defaults was approximately 19 farms per 1,000 farms, as compared with 22 and 23 farms per 1,000 in preceding years. Much improvement is necessary to restore normal conditions. The foreclosure rate is still very high, and the farm bankruptcy rate is seven times the pre-war figure. On the other hand, the transfer of farms by voluntary purchase or sale is far below normal. As a result, much land is held by mortgagees under conditions which seem likely to make it a problem for some time. It is unfortunately still true that in discussing the farm real estate situation we must record improvement in terms of lessened damage rather than in terms of positive gain. Nevertheless, the situation is clearing, and it may shortly be possible to exchange negative for positive terms in describing developments.

It is desirable to guard against a tendency, often shown heretofore, for farm real estate values to be bid out of a reasonable relationship to the farm earnings that can be conservatively expected. In the postwar boom period 6 per cent mortgages on land yielding not more than 3 per cent on their capitalization were not uncommon. Farms thus overcapitalized carried a heavy burden of charges, and had an insufficient margin of safety when farm earnings declined. Under such conditions farm ownership tended to lose its appeal, for tenancy was often more profitable.

Overoptimism in farm-land valuations tends, since the error must eventually be corrected, to be followed by a period of undue pessimism, during which values are driven below the level justified by earnings. Credit may then be unduly restricted. In the first case, easy credit causes prices to be bid up excessively, while in the second case restricted credit causes prices to fall too low. More study of the factors that ultimately determine farm-land values is required, so that the farm realty market will be less influenced by uninformed opinion. Fundamental research combined with accurate and continuous current information should help to discover the basis upon which farm-land values should be stabilized.

Necessity of Sound Capitalization

Agriculture can not be continuously prosperous unless the structure of its capitalization is sound. Mistakes in this field may largely offset the value of efficient farm management, good adjustment of production to demand, orderly marketing, and intelligent use of land resources. Adequate research and analysis of the farm-land-value situation would have disclosed some of the weaknesses that came to light after the war, and served as a useful warning against inflation.

Though farm valuations are not inflated to-day, they may again become so if precautions are not taken. Adequate research is the first necessity. The department is engaged in studies as comprehensive as its resources for the work permit.

USE OF POWER MACHINERY

In recent years a rapid technical evolution has taken place in American agriculture, characterized distinctively by a substitution of mechanical power for human and animal labor. Most of the change has developed since the European war. Comparisons limited to the postwar period are not available. Some idea of the magnitude of the change can be gained, however, from the fact that between 1870 and 1925 the average area of improved land cultivated per farm worker increased from 32 to 49 acres, or slightly more than 50 per cent. In the same period the value of machinery on farms in terms of 1913 dollars increased tenfold, or from $270,000,000 to $2,700,000,000. In value of machinery per farm worker, in terms of 1913 dollars, the increase was from $36 in 1870 to $200 in 1925, a gain of 455 per cent. American farm workers using mechanical power now produce from two to five times as much as similar workers in the older countries of Europe. Though all parts of the country have been affected more or less by this technical progress, the western grain-growing areas have been affected most. Mechanical power is rapidly replacing horsepower in heavy work such as plowing and disking in all parts of the country, and in the last few years machinery has become important for cultivating row crops and for grain harvesting.

The introduction of tractors suitable for cultivating corn, cotton, and potatoes is comparatively recent. Previously the standard method of cultivating corn was with the 2-horse, 1-row cultivator. Under the old conditions one man could cultivate from 30 to 50 acres of corn, according to the topography and the character of the soil. With one of the new power cultivators equipped for 4-row cultivation, one man can cultivate from 160 to 200 acres of corn. In the same manner he can cultivate about the same acreage of cotton. This gain in the acreage one man can cultivate tends to increase the size of farms in the central Corn Belt and in the western part of the Cotton Belt. It materially reduces unit costs of production. Following the introduction of the tractor-cultivator the number of horses needed on corn and cotton farms decreased sharply. From 1918 to 1928 the number of farm horses in the United States decreased more than 7,000,000 head. Simultaneously the automobile and the truck practically replaced horses in cities. There resulted a marked decrease in the demand for corn, oats, and hay. However, the decrease in the demand for corn for horse feed was partly offset by a slight reduction in the acreage of corn and by increases in other kinds of farm stock.

The Increase in Tractors

An indication of the rapidly growing use of mechanical power on farms is the increase in the number of tractors manufactured in this country. In 1927 the number produced was 62,742. Though this

was double the production of 1916, it was less than half the number turned out in 1928. It is estimated that in 1928 there were approximately 853,000 tractors on American farms. Tractors have recently been greatly improved in design and construction. The early farm tractors were large and proved unwieldy on land already under cultivation. Then followed a reaction toward very small tractors. To-day a middle course is followed; the tractors now turned out are somewhat larger than those that were popular a few years ago. In the northern Great Plains region the 3-plow and 4-plow tractor is coming rapidly into use, and there is some demand for 6-plow tractors.

More strongly built implements to hitch to these tractors are required. Manufacturers have been cautious about producing such equipment, fearing that their necessarily higher price might interfere with sales. It is now coming to be recognized, however, that the great power of the modern tractor necessitates strongly built attachments. A typical example of the labor-saving effected by the use of the tractor is given in a recent study made by the University of Arkansas, which showed that a rice farmer in that State using tractor equipment could accomplish three, four, and even five times as much as he could with earlier methods. In one rice-growing county in Arkansas the survey showed 1,507 tractors, or 1 for every 63 acres of rice.

In many western localities farmers have increased the size of their implements, and the area of land they till, by using large teams. This is practicable through the use of hitches that compel each unit of the team to do its share of the work. Teams of 12 to 20 horses are not uncommon for plowing, disking, harrowing, and seeding, and on some of the combines in the Pacific Northwestern States as many as 32 horses are used effectively. A contest is on between the tractor and the big team, the outcome of which is not yet determined in many localities.

Trend Toward Larger Farms

Large power units of farm equipment are undoubtedly the chief cause of the recently accelerated trend toward an increase in the size of farms. It has been estimated that from 1915 to 1917 Montana had about 35,000 wheat farmers, many of them operating half-section or small farms. To-day Montana probably has not more than 14,000 wheat farmers. These men, however, are handling more acres and doing the work better than it was formerly done by 35,000 farmers. New types of implements for cultivating summer fallow have helped to increase the size of farms in the Plains and in the Mountain States of the West. One of these implements is called the "duckfoot." Use of the duckfoot first became general in the Columbia River Basin, and spread therefrom to Montana and other States east of the Rockies. Some wheat growers in the State of Washington substitute this implement for the plow. One farmer in that State, using 16-horse teams on 12-foot duckfoot cultivators as a substitute for plows, is able to farm 1,600 acres per man. Another new implement that is gaining in popularity in the central and northern Plains region is the 1-way disk summer-fallow cultivator, which permits a more effective cultivation and results in better yields.

Outstanding in postwar mechanical developments in agriculture is the rise of the combined harvester-thresher (known everywhere among farmers as the "combine"), in the territory east of the Rockies, where it was formerly believed that wheat could not be left standing until ripe enough to be harvested by the combine. When the practicability of the new method of harvesting was demonstrated for the Plains region, the introduction of the combine was extremely rapid. In 1926, 30 per cent of the Kansas wheat crop was harvested by the combine, 8,274 machines being used in the work. In 1928 Kansas had 20,000 combines. The combine appeared in North Dakota for the first time in 1925. Three years later in that State 1,000 combines were used in small-grain harvesting.

Wheat Harvesting by "Combine"

This year more than half of our hard winter wheat, one-fifth of our hard spring wheat, and a smaller proportion of our soft winter wheat was harvested by combines. This machine eliminates the grain binder, the shocking of the wheat, stacking, and the use of the threshing machine. It reduces the cost of harvesting to a small fraction of what it formerly was. A serious problem connected with the use of the combine is the fact that much combined grain contains more moisture than grain may safely contain when put in a bin. Accordingly, means are being studied whereby the moisture content of grain may be reduced before it is placed in storage. Indications are that a solution of this problem will be found.

Increased use of automobiles and trucks for road work has greatly extended the market area available to farmers. In 1926 farmers on the eastern shore of Maryland and Virginia moved 1,162 carloads of strawberries by truck. Some of the shipments went as far north as Albany, N. Y., and Boston, Mass. Grapes from Michigan are to-day moved as far as Indianapolis, Ind. In some instances hauling by automobile and truck saves two-thirds of the farmer's time in delivering his products. A recent study showed that before the introduction of trucks the market points used by a certain group of farmers averaged 7 miles from the farm. After the introduction of trucks the average distance to market points was 18 miles.

Cincinnati, Indianapolis, Detroit, Milwaukee, Minneapolis, and St. Paul receive 90 per cent of their milk supply by motor truck. Receipts of hogs, cattle, calves, and sheep by truck have increased at most of the large livestock markets. In 1928 more than 50 per cent of the hogs received at Indianapolis, Oklahoma City, and Sioux City, and an equal proportion of the cattle received at Indianapolis, the calves received at St. Joseph, and the sheep received at Indianapolis, Louisville, and Oklahoma City arrived by other means than rail transportation, mostly by truck. At Chicago, the percentage, while increasing, has remained negligible. In the last five years the number of Illinois hogs marketed by truck has risen from 7.9 to 22.5 per cent of the total marketed. This change has been accompanied by an increase in the percentage of all hogs moving directly from farm to packing plant. Fourteen per cent of the fruits and vegetables grown on the Delaware-Maryland-Virginia Peninsula, including

more than half of the more perishable commodities, such as strawberries, peaches, and cucumbers left that area by motor truck in 1928. Fourteen per cent of the receipts of fruits and vegetables at Newark during 1928, at least 5 per cent of those at San Francisco, and at least 9 per cent of those at Boston, arrived by truck. Perishable commodities produced within 200 miles of their market seem to offer the principal field for truck movement.

FARM RELIEF

Outstanding among the events of 1929 was the passage of the agricultural marketing act. This measure, the result of eight years of discussion in the press, in agricultural circles, and in Congress, is essentially intended to enable agriculture to effect a better adjustment of production to demand and a more efficient system of marketing. Its adoption closed a period of debate and opened one of action. Though opinion was sharply divided during the preparation of the law, its enactment was hailed with general approval and satisfaction.

This is not the place for a detailed analysis of the agricultural marketing act, nor for any forecast of its results. In view of the importance of the measure to agriculture and to the Nation, however, it seems appropriate to mention its principal provisions and to note some of the conditions with which it must deal. It sets up a Federal Farm Board with unusual powers and resources. It contemplates that rural prosperity may be increased by the creation of a new agency to function parallel with other governmental establishments in the furtherance of a broad and constructive program for agriculture.

The program as set forth in the agricultural marketing act contemplates: (1) Strengthening the bargaining power of producers and increasing the efficiency of their marketing operations through the development of effective cooperative-selling associations, stabilization corporations, and clearing houses; (2) stabilizing the supply of agricultural products and minimizing fluctuations in prices by preventing surplus production in so far as possible, and by effective distribution of surpluses once produced; (3) assisting in developing a national agricultural policy with reference to land utilization, marginal lands, and, in general, the control of the farm-land area; (4) assisting in broadening markets for agricultural products at home and abroad and, more specifically, through the development of by-products of and new uses for agricultural commodities; (5) helping to correct maladjustments in transportation conditions that work hardships on agricultural producers in any section of the country; and (6) assisting in minimizing undesirable speculation in agricultural commodities and eliminating waste in their distribution.

In short, while in the act itself stress is laid upon the effective organization of cooperative-marketing associations as a means of improving farm conditions, it is apparent that Congress contemplated a broad approach to the problem, embracing all major economic factors that materially influence farm incomes.

Act Is Specific as to Methods

The agricultural marketing act is specific regarding the methods which it is expected the Federal Farm Board will use in furthering this program. It directs that education in the principles and practices of cooperative marketing of agricultural products be energetically promoted. It also directs the board to promote the organization and development of effective cooperative-marketing associations. It contemplates that where conditions require such action, the board will assist in the organization of stabilization corporations and clearing houses to assist in tempering the influence of abnormal surpluses upon prices. It provides for far-reaching financial assistance to cooperative-marketing associations and, for this purpose, authorizes a revolving fund of $500,000,000. It contemplates that the board will utilize the services and the results of research of other organizations in the development of its program.

In creating this new agency Congress evidently intended that it should not supersede the Department of Agriculture and other existing agencies, but should coordinate its activities with those agencies. Close cooperation between the Federal Farm Board and the Department of Agriculture is necessary. The terms of the agricultural marketing act show that Congress did not intend to create a new Federal agency with duties overlapping those of this department. Such a course would weaken one or both organizations. But the board is clearly expected to supplement some of the department's work. In the great task of reorganizing agriculture in many important respects, the board will be on the firing line while this department will, to a large extent, make and supply ammunition. As an organization for research and for service to agriculture and for the enforcement of regulatory laws, the department will continue to function as it has done in the past. It is not the suitable agency to make practical application of all the facts its investigations bring to light, nor has it the legal authority to do so. In this field the board can do what the department can not do.

Opportunity for Cooperation

Every opportunity exists, therefore, for harmonious and fruitful cooperation between these two Federal agencies. The department's crop and livestock reporting services, its market-news and outlook reports, its work on grading and standardization, and its studies of agricultural prices, cooperation, land utilization, and other agricultural matters, will undoubtedly be of great assistance to the board. Doubtless also the board will call upon the department for special research and service work. Agricultural investigations and services are all interrelated. It is therefore not improbable that the department will be called on to assist the board in many ways related to the immediate and the long-time purposes of the agricultural marketing act.

By a curious coincidence the agricultural situation, when the Federal Farm Board began its work, was unusually free from difficulties due to surplus production. It need scarcely be said, however, that surpluses will recur. Wise planning may establish a better average balance between production and supply, but can not wholly obviate

the effect of exceptionally favorable weather on production. Seasonal surpluses will be produced inevitably from time to time. The great task of the Federal Farm Board is to assist agriculture in making surpluses less frequent, less burdensome, and easier to handle.

Much more is required than merely the financing of cooperative associations. This is clear from a glance at the many reports that have been made in recent years on the condition of American agriculture by public and independent agencies. Among these may be cited a report in 1926 by the National Industrial Conference Board, and another in the same year by an advisory committee of the Social Service Council; a report in 1927 by a special committee of the Association of Land Grant Colleges and Universities; a report prepared in 1927 by a business men's commission acting under the joint auspices of the Chamber of Commerce of the United States and the National Industrial Conference Board; and a report in August, 1928, by a special committee of the United States Chamber of Commerce.

Though naturally varying in their emphasis on different aspects of the agricultural problem, these reports had much in common. They drew attention to the results of the world-wide economic disturbances occasioned by the war, to the long-time effects of unwise land utilization, to the seasonal effects of wrongly planned acreage and livestock breeding, to the wastes of unregulated competition and haphazard marketing, and to the hardships sometimes imposed on agriculture by an inadequate credit system. Evils thus deeply rooted can not be remedied overnight. Nevertheless, I think we may say that the machinery set up under the agricultural marketing act promises a more effective and continuous remedy than has heretofore been possible.

Status of Cooperatives

In view of the important functions assigned to the cooperative associations in the Federal Farm Board's program, it will be useful to glance at the status of the American cooperative movement. What cooperative machinery lies ready to the board's hand? What foundation has been laid for future building? It is satisfying to report that the current year has seen good progress in cooperative marketing, in general efficiency as well as in membership and in business done. Increased attention has been given to the development of large-scale organizations, to the centralization of sales, and to the possibilities of regional federation. In recent years membership in cooperative associations and their volume of business have increased more rapidly than the number of associations. In other words, the cooperative units have become larger. This tendency, which promises to continue, lessens selling competition and facilitates efficient distribution. It is in line with the Federal Farm Board's expressed desire that cooperative development shall be effected primarily through a strengthening and a closer integration of existing associations, rather than by causing a new crop of associations to spring up.

The first cooperative associations in this country were local bodies formed to provide better and cheaper marketing facilities. In some areas these developed into regional organizations. Eventually asso-

ciations were set up for cooperative selling in the terminal livestock and grain markets. Livestock cooperative agencies now operate in 26 important livestock markets, 12 of them in affiliation with the National Producers' Livestock Marketing Association, and 9 with Farmers Union organizations. The others are independent. Some progress has been made toward the centralization of grain marketing, though in this field differences of opinion as to methods have not yet been settled. Hence, centralized grain marketing is in a relatively early stage. Large federations of cooperative creameries and cheese factories have been developed through the federation of independent local units. Numerous large dairy cooperative associations are affiliated in a national body. In fact, the last four or five years have seen a very strong trend toward an increase in the size of cooperative units and a disposition among them to federate for coordinated marketing. One striking index of the present status of the American cooperative movement may be seen in the fact that more than 200 farmer-owned associations now each transact an annual business exceeding $1,000,000.

Units Largely Unrelated

Nevertheless, the movement is still made up largely of unrelated units that inevitably work to some extent at cross-purposes. More than 90 per cent of the associations now functioning are independent local or regional bodies having little contact with other cooperatives. More than 300 associations market potatoes. There are 6 or 7 large organizations that handle from 1,500 to 8,000 cars annually, but this represents only a fraction of our potato production. As a result, potato selling is highly competitive, and little progress has been made in adjusting the production of potatoes to the probable demand. Efforts toward coordinated production and marketing in one region tend to be nullified by unregulated production and haphazard marketing elsewhere. The same condition exists in many other branches of agriculture. Centralized organizations for coordinated marketing are indispensable if full advantage is to be taken of the agricultural marketing act.

Under the agricultural marketing act rapid progress in the coordination of cooperative marketing may be expected, inasmuch as greater unity of effort among producers' organizations is a leading object of the act. Support is not to be given to the upbuilding of unrelated cooperative units in the same branch of agriculture, since to do so would increase wasteful competition in marketing between producing groups and between producing regions. Thinking in local or regional terms, necessary in the early stages of the cooperative movement, must now be supplemented by thinking in commodity terms. Such a view of cooperative requirements is entirely consistent with the continued growth of local and regional associations, provided these become units in a coordinated movement. Time will be required to work out the necessary details of this principle. But when it is applied, an important step will have been taken toward placing agriculture on a parity from a business standpoint with other industries.

FARM TAXATION

Taxes on farm property continued to increase slightly during the past year. For the country as a whole the increase amounted to about 1½ per cent. In the east North Central States there was a slight decline; taxes in the Middle Atlantic and the Mountain States remained at the level of the previous year. In all other sections increases occurred. The normal tendency of public expenditures is to increase. Hence reduction in farm taxes is not usually to be sought through general reductions in public expenditure, but rather through readjustments tending to equalize tax burdens among all tax-paying groups.

Farm taxation mainly concerns State and local governmental units rather than the Federal Government. Accordingly, the department's studies of the problem are largely conducted in cooperation with research organizations in the several States. Research results brought together within the past year indicate that during the last five years taxes have taken about one-third of the net rent on rented farms. This fact gives some idea of the tax burden on all farm property. Detailed studies in 14 States extending from New Jersey to Washington and as far south as South Carolina provided the basis for this estimate. It is estimated that in 1928 farmers paid $1.42 in taxes on each $100 of actual value of their real estate. This ratio should not be confused with the tax rate, which because of the general custom of underassessing all property would average much higher.

Chief among the reasons for the excessive weight of farm taxation are the dependence of local governmental finance on the general-property tax, and the fact that farmers, more than any other group, have their productive property in a form that can not be missed by the assessor. State governments are making increasing use of sources other than general property from which to secure revenue, but little use is made of such sources by local governmental units.

Broadening Assessment Basis

Changes in taxation that broaden the assessment basis of the general-property tax or that use reasonable indices of tax-paying ability other than the ownership of tangible property can not fail to be of advantage to farmers. Along with or perhaps in advance of such changes must go improvement in the administration of the tax laws. The averages that have been quoted do not indicate the great differences that exist in the weight of taxes from farm to farm. When taxes were light, inequality in their incidence was of minor importance. Even the persons most highly taxed were not taxed so heavily as to feel injured. Injustice existed, but did not make itself acutely evident. Now, however, many persons in the group that is taxed materially above the average find their tax burden unbearable.

Recent studies in a Western State indicated that, because of inequalities in assessment, owners of half the real estate paid two-thirds of the taxes. This condition existed in the State as a whole and to a greater or less degree in its local administrative units.

Studies in other States showed similar conditions. Improved assessment would lower the taxes of many now unfairly burdened. It would necessarily increase the taxes of persons now assessed on a basis lower than the average, but the result would be more equitable than is the present situation. Improved assessment would also put on the tax roll property that heretofore has escaped taxation. Since the property added would be mainly nonagricultural, the burden on farm property would be lowered. In many parts of the country improvement is possible in the collection as well as in the assessment of taxes.

No single program of tax reform could be devised to fit all the States. It is worth noting, however, that State taxes on personal income are being increasingly used to raise revenue. In some States a low-rate tax on intangibles has materially increased the revenue secured from intangible property. The sales tax on gasoline is universal and yields much revenue and State sales taxes on nonessential commodities make a small contribution. Severance taxes, levied when a natural resource is used up, yield large revenues in certain States that have mineral resources. By adopting one or more of these taxes a State may relieve tangible property measurably.

Increased State Aid for Roads and Schools

Increased State aid in the building and maintenance of roads and in paying the costs of education is broadening the tax basis for the support of these public services in some States. Few States, however, have gone as far as they might in assisting in this way their communities of relatively low tax-paying ability. Such communities, which are often farming regions, are usually forced by State laws to maintain high standards of education. The State should accept the responsibility of helping to maintain such standards, when the burden on local property exceeds certain limits. Much of the desired improvement in the farm-tax situation can come only through the action of the community as a whole. It is necessary to consider not only farm taxes, but the use that is made of the proceeds. Sometimes public expenditures may advantageously be increased. For effective tax reform, this fact must be borne in mind, as well as all pertinent facts relating to tax burdens.

FARM CREDIT

Farm credit remains costly in many parts of the United States notwithstanding the great improvement that has been made in agricultural-credit facilities during the last 10 or 15 years. The Federal reserve act of 1913, the farm loan act of 1916, and the intermediate credit act of 1923 brought about favorable changes of fundamental importance. Further progress may be expected from the financial provisions of the agricultural marketing act of 1929. As yet, however, the potentialities of our credit system are reflected very imperfectly in the terms and conditions under which many farmers obtain credit. In many instances the gap between the supply of credit at central money markets and the farmers' credit requirements has not yet been bridged. In the case of production and marketing credit, local facilities through which the farmer can avail himself

of the credit channels established by the Federal reserve and the intermediate credit acts are too often lacking. In the case of mortgage credit the facilities are generally within the farmer's reach, but want of knowledge concerning them frequently prevents their use. In parts of the South, for example, a substantial proportion of the credit used by the farmers is obtained by them from merchants rather than from credit institutions. It takes the form of time payments for goods purchased. A study made by the department in the Southeastern States showed that the cost of such credit averaged more than 25 per cent per annum. Credit for fertilizer obtained on this plan generally costs about 35 per cent. Farmers having both merchant credit and bank credit paid from two to four times as much for the former as for the latter. Average credit costs for all the short-term agricultural credit used, including cash credit from banks, ran from 10 to 15 per cent. Even land mortgages on good security often carried 8 to 10 per cent interest, although the rate charged by the Federal farm loan system was less than 6 per cent. Frequently the cost of loans was out of all reasonable proportion to the risk.

Financial Isolation of Farm Communities

The financial isolation of farm communities has much to do with the relatively high cost of agricultural credit. Such isolation permits a wide range of charges, and great fluctuations in the local supply of credit. Commercial banks, the most important source of short-term credit for agriculture, are too numerous and too small in some areas. This is a more or less inevitable outgrowth of competition for the loan business and of trying to bring credit facilities within convenient reach of all prospective borrowers. The situation has been modified but not yet corrected by improved transportation. Country banks usually concentrate their loans in very restricted areas, with a corresponding concentration of risks. As a result, both local and nation-wide agricultural depressions speedily exhaust their resources. As is well known, country-bank failures have been exceedingly numerous in recent years. These institutions were subjected to severe strain as a result of war-time inflation followed by monetary deflation and by depression of agricultural values. The situation in local banking is improving as a result of economic progress in agriculture generally and because of better management of banks and a strengthening here and there in State laws.

Improvement is not so much a question of providing new credit institutions as of improving the functioning of those in existence. Much might be accomplished on the initiative of the lending institutions themselves. Such institutions, particularly in regions where crop specialization is the rule, often fail to see the need and wisdom of making loans for side-line enterprises, such as dairying or livestock raising. Hence the farmers' demands for such credit often go unsatisfied. In regions where such enterprises are relatively undeveloped, they may afford a profitable opportunity for utilizing labor time that would otherwise be lost. Credit institutions are often slow to recognize new opportunities created by improved machinery and by technical progress generally for the profitable use of credit in agriculture. A more progressive attitude on the part of such in-

stitutions would enable many farmers to increase their income substantially.

Farmers themselves, of course, can help toward the improvement of the credit situation. As individuals they can do so by observing sound principles in the use of credit. During a period of high money rates, for example, it is obviously desirable, whenever possible, to defer mortgage financing. It is also desirable that more farmers should recognize the advantage of obtaining a greater proportion of their necessary credit from specialized credit institutions, rather than from merchants who ought not to be asked to do a banking business. Study of market prospects, before applying for production loans, will help the individual farmer to improve the general credit situation. Collectively, farmers have very extensive opportunities for bringing about improvement. Since the intermediate credit act was passed large amounts of credit have been utilized successfully by the cooperative associations.

Their field of opportunity is widened by the enactment of the new agricultural marketing act, which provides for loans to cooperative associations for the acquisition of plant and equipment. It thus meets an urgent need. This act also provides for loans to assist in the formation of clearing-house associations and in the extension of cooperative membership. Loans made available for these purposes will constitute an addition to the existing farm-credit structure, rather than a substitute for any part of it and are, therefore, a distinctly new and important contribution to the solution of the farm-credit problem. Commodity loans which the Federal Farm Board is authorized to grant, supplementing loans from existing agencies, should be conspicuously serviceable in relieving farmers from compulsion to market their crops at harvest time regardless of price conditions.

Field for State Action

In the improvement of agricultural credit, there is a broad field for action by the several States. Most banks that serve farmers operate under State supervision. Improved banking laws are needed in many States. It is necessary to insure increased safety for deposits, as well as to improve credit facilities and credit practice. Some States maintain legal restrictions on interest rates that really make credit dearer. When legal rates are lower than those quoted in central markets for loans with a favorable term and good security the flow of credit into the community is diminished and loanable funds within the community tend to be diverted into outside investments. With resulting scarcity of local credit, farmers may thus be forced to resort to costly merchant credit. Regulations that attempt to set aside economic laws need to be replaced with more practical ones, in harmony with the principles of money and banking and at the same time properly adapted to agricultural requirements.

MOVEMENTS OF POPULATION

Evidence that the drift of population from the country to the town continues is contained in a survey made by this department covering 1928. Our farm population at the end of 1928, according

to this estimate, was the smallest in more than 20 years. Though the gross movement of persons from the farms was somewhat smaller in 1928 than in 1927 and 1926, it comprised the formidable total of 1,960,000 persons. This figure was largely offset, however, by the movement of 1,362,000 persons from cities, leaving a net movement of 598,000 persons from the farms to the cities. The corresponding net movement for 1927 was 604,000 persons; for 1926, 1,020,000; for 1925, 834,000; for 1924, 679,000; for 1922, 1,120,000. No estimate was made for 1923. Farm population as of January 1, 1929, was estimated at 27,511,000, as compared with 32,076,960 as estimated by the census for January 1, 1910.

In these cross currents of population, the net movement from the farms to the cities is not synonymous with the net annual loss of farm population. This latter figure must be calculated after allowing for birth and death rates. A birth rate much higher than the death rate on farms makes the net annual loss of population much less than the annual migration figures would suggest. Thus in 1928, the net loss of farm population, with allowance made for birth and mortality on the farm, was estimated at 188,000 persons, as compared with 193,000 in 1927, 649,000 in 1926, 441,000 in 1925, and a total of 2,000,000 in the years 1920 to 1925.

Loss of population in the country due to townward migration has taken place in parts of the United States for many decades. Though the postwar depression increased the loss, it did not account for it wholly. Technical progress on the farm, as a result of which it becomes possible to feed an increasing population with less farm labor, has much to do with the phenomenon. Farming processes in the United States have been mechanized at an extraordinary rate since the war. This progress, with its associated labor-saving, was not sufficiently offset by an increase in the demand for farm products. By an inevitable necessity, therefore, the farm population declined. Since the net loss has declined quite steadily in the last few years, the exceptional forces responsible for the extraordinarily heavy postwar movement appear to be losing momentum.

The Probable Trend

Future movements of population from the country to the town will be influenced by the degree of prosperity prevailing in agriculture, by the rate at which machinery is substituted for human labor, by further developments of scientific production, and by the growth of markets at home and abroad. In all probability the balance between urban and farm population will continue to run in favor of the towns. Our concern is, however, that the movement of population, at whatever rate it may take place, shall be in harmony with the Nation's social and economic advance. When it is too great, as it may possibly have been in some years recently, the agricultural industry is deprived of necessary man power, and compensating adjustments are made necessary at great national expense. When the movement is too small, competition in agriculture rises to a point at which farm profits tend to disappear. Some evidence exists that the population movement is approaching stabilization on a basis consistent with the national good, and that necessary

changes in population elements will be brought about rapidly enough to avoid hardship and distress.

FARM LIVING STANDARDS

In the last eight years the department has accumulated considerable data on family-living standards on the farm. Though sufficient progress has not been made to permit a thoroughgoing comparison between farm standards and city standards, much has been learned about the living standards of certain groups of farmers. It has been demonstrated, for example, that family-living standards are deficient on a large proportion of the small farms in the country. That is an important fact necessitating remedial action, for small farms are relatively more numerous than is commonly supposed. In 1925, when the average number of acres per farm in the United States was 145, 38 per cent of all the farms were under 50 acres and 60 per cent were under 100 acres.

Family-living standards are of course not low on all small farms. Many small farms devoted to varying types of agriculture produce net incomes equal to the average on larger places. It is nevertheless true that a majority of the small farms in the United States are low income producing and low-value farms. Such farms in 1925 were estimated to be worth, for land and buildings, less than $4,000 on the average. A considerable proportion had a value of $2,000 or less. Many small farms have poor soil and difficult surface conditions. Probably nearly 40 per cent of the country's farm population lives on small farms of poor and difficult land, on a standard of living far below what is common on large farms.

Farm families belonging to this low-standard group are numerous in nearly all the States. How to improve their condition is a complex problem involving economic, social, and human factors. It is not primarily a question of tenancy versus ownership, nor a question of cropper cultivation versus cultivation by hired labor, though these elements may be present. Land-tenure conditions as a criterion for high or low standards of living may sometimes be overemphasized at the expense of more important factors. The first step toward improvement must be a correct analysis of the problem.

Side-Line Occupations Off the Farm

On many small farms only about half the cash income of the farm family comes from the farm business. The remainder is earned by the operator or by members of his family in occupations off the farm. In addition to the cash income obtained from the farm and income obtained in outside occupations, the small farm itself furnishes food, fuel, housing, etc. But all these sources combined commonly do not provide a satisfactory living. Often the difficulty is increased by the farm operator's pessimism as to the possibility of getting more income from the farm itself. He is not generally as quick to take advantage of scientific methods as is the larger farm operator. Yields per acre, per cow, per hog, or per hen on the small farms of the United States average lower than on the larger farms, whereas in certain European countries the opposite is the case. Too often,

moreover, the economic efficiency of the farm family is impaired by lack of adequate opportunities for education, recreation, and the preservation of health.

Further study of the small-farm problem as a whole is urgently necessary. A rough classification of such farms seems practicable and indicates the application of different remedies in different situations. (1) We may distinguish small farms whose earning power can not be materially increased through soil improvement or improved management. (2) There are numerous small tenant or cropper farms which form parts of a large holding or plantation. Often the soil of such farms can be improved materially and their production increased by efficient centralized supervision. (3) There are many small farms operated by their owners, the soil of which could be materially improved and upon which a better farm practice would bring much better returns. Then there are small farms that furnish a fair living place and some food, fuel, and other necessities, while permitting members of the farm family to work at outside jobs.

Different Remedies Required

These different kinds of small farms obviously call for different means of increasing their power to furnish a satisfactory standard of living. Farm management and marketing methods should be adapted specifically to each type. It should often be possible to encourage the development of rural industries adapted to the part-time employment of the small operator and his family. In certain areas where the economic operation of small farms is impracticable, State agencies should discourage the small farm. On the other hand, it is well to recognize that a place exists for the small farm providing a lower all-round income than the larger farm usually produces, since many families may do better on such small farms than they would anywhere else.

Effective action to raise living standards on our small farms is necessary, not only in the interest of the farm people immediately concerned, but in the interest of the Nation. These farms are a source of population as well as of food supply. They send their surplus population to the towns and cities. Hence the entire Nation suffers when living conditions on the small farm make it difficult to rear and educate young people adequately there. Not agriculture alone, but our entire national life stands to benefit from whatever may be accomplished toward the establishment of a satisfactory standard of living on the small farms.

AGRICULTURAL EXPORTS

Total exports of agricultural products, excluding forest products, amounted to $1,847,567,000 in the fiscal year 1928–29, an increase of about 2 per cent over the previous year. Gains were made in the exports of cotton, tobacco, pork products, fruit, and feed grains. Shipments of wheat declined. Agricultural exports in the past year made up only 33 per cent of our total exports of all commodities, the smallest percentage, with the exception of that for 1917–18, on record.

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Exports of cotton during 1928–29 increased about 7 per cent over those of the preceding season. Great Britain, Japan, and Italy took substantially larger quantities of American cotton but exports to Germany, France, and Russia declined. The present season opened with activity of foreign cotton mills as a whole apparently on a lower level than last year. Our exports of wheat declined about 25 per cent last season as compared with 1927–28, in spite of a somewhat larger wheat crop. There was increased competition from large wheat crops in Canada and the Southern Hemisphere. Moreover, increased European production of wheat in 1928 reduced Europe's import requirements. Exports of corn, barley, and oats in 1928–29 were materially above those of the preceding year, largely because of an improved European demand following a poor harvest of feed grain crops in Europe.

Exports of flue-cured tobacco, which now constitute almost three-fourths of our total leaf-tobacco exports, increased 26 per cent over those in 1927–28. The increase was due almost entirely to the fact that very large shipments were made to China during the last six months of 1928 in anticipation of higher import duties. Exports of flue-cured tobacco to China in the first half of 1929 were much smaller. Exports of air-cured and fire-cured tobacco were smaller in 1928–29 than in 1927–28, and the outlook for future exports of these types is not so favorable as for flue-cured tobacco.

Increased Exports of Pork Products

Fewer hogs and reduced pork production in Europe resulted in larger exports of pork products and lard from the United States during the last fiscal year. Exports of cured pork increased 3 per cent and those of lard 9 per cent. The increased quantities of pork were exported at higher prices. Lard prices, however, were lower than in 1927–28.

Exports of fruit increased largely last season. Shipments of boxed apples to foreign markets were the largest on record. Exports of barreled apples were close to the record figure attained in 1926–27, when the crop in the eastern barreled-apple States was much larger than that of last year. Poor apple crops in Europe resulted in greatly increased takings of American apples by continental markets. Exports of oranges and grapefruit continued to increase. Shipments of California oranges to Great Britain during the past spring and summer were unusually heavy. A record production of prunes and raisins in 1928 contributed to a further expansion in the exports of these products. Some of the increase in the prune exports was due to reduced competition in European markets from Yugoslav prunes.

THE TARIFF

It has come to be more generally recognized in recent years that tariff protection for the farmer is a necessary part of a sound national agricultural policy. American agriculture was formerly more dependent on foreign market conditions than it is to-day; and many students doubted whether tariffs could be effective on farm products. It is a truism that goods produced largely for export usually have their prices determined in the export trade.

Since 1900, however, agricultural exports have been a diminishing part of our total agricultural production. From 1924 to 1926, inclusive, the value of our exports of animal products and of crops not fed to livestock was only 16 per cent of the value of our total production of such products, whereas it was within 24 per cent for the period 1899 to 1903. Simultaneously our imports of agricultural products increased. On the other hand our industrial exports became an increasing part of our industrial production.

American agriculture is still far from being on a domestic basis, and will undoubtedly have large quantities of certain products to export for many years. Nevertheless, it can profit increasingly from tariff protection. This is true even of crops that are quite largely exported. Hence the consideration by Congress of a tariff bill providing substantial increases on the duties of many agricultural products is a happy augury. This Nation is committed to the protective principle. The tariff legislation in prospect, coupled with the trend in our foreign trade, promises to make that principle more effective for agriculture. There is no need to discuss the tariff schedules proposed. It is sufficient to point out that agriculture benefits substantially from existing duties, and can use increased protection. The tariff conspicuously assists producers of flax, cane and beet sugar, fruit, beef cattle, sheep and wool, and dairy products. Our beef-cattle industry has been on a domestic basis for years. Under the protective policy our sheep industry, though faced with keen foreign competition, is expanding. Our dairy industry has shifted from an export position to one in which it barely meets domestic requirements. It can thus benefit materially by import duties on its principal products. Without tariff protection the price of butter would be materially reduced in the season of low production in the United States, and the incentive for production in that season would be diminished. Though we export large quantities of lard and other pork products, and import only small quantities, tariff duties on these products can give some protection against imports from Canada. Duties on vegetable fats and oils can protect the domestic market for lard indirectly, and to some extent the domestic market for other pork products. Such duties can also protect the producers of cottonseed and dairy products.

Tariff Protection on Corn and Wheat

Tariff protection can be effective on corn and wheat, though our imports of these commodities are small. Duties on corn can protect the coast markets against Argentine corn, particularly in seasons when the Argentine crop is large. Without such protection corn can not be shipped in such seasons from our corn States into coast markets in competition with corn from Argentina. Tariff protection is effective on wheat when the Canadian crop is large and the United States spring wheat crop is short. Even our cotton industry can be benefited by a protective policy though we export half our cotton. Protection against the importation of long-staple cotton would strengthen the domestic market for the longer American staples. In short, agriculture is by no means on a world-market basis exclusively, but is well placed to share the benefits of our protective system.

HELPING THE FARMER LOOK AHEAD

Increased attention was given to the issuance of economic information in a usable form. It is now six years since the department began its system of outlook reports as an aid to farmers in adjusting their production. In the main these reports necessarily present a national rather than a local point of view, and need to be supplemented with regional and local information. Accordingly, the outlook work as now conducted involves close cooperation between Federal and State research and extension workers, so that data about main trends in production and prices may be related to the requirements of particular farms. Not all the producers of a given commodity should increase their production when the prospect is for favorable prices, nor should they all curtail their output when the prospect is less favorable. Much depends on whether the individual farmer's costs of production are relatively high or relatively low. It is therefore necessary to combine general economic information with farm-management studies. This has been done extensively of late with gratifying results.

In the preparation of the national outlook report, workers from every State participated. Some States had several representatives at the outlook conferences in Washington. In turn members of the department cooperated with State economists and extension officials in drawing up regional applications of the main report. Thirty-eight State agricultural colleges issued State outlook reports. Federal economists also cooperated with county agents in interpretations of the outlook material on a county basis. Economic charts proved effective in promoting better adjustments of production. Some idea of the scale on which the outlook extension work was conducted is given by the fact that 250,000 copies of the national and 215,203 copies of the State outlook reports were distributed. More than 2,500 outlook extension meetings were held, through which more than 100,000 farmers were reached directly and thousands of others indirectly. Outlook information was also distributed in a national radio broadcast including 32 stations. The widespread interest shown in the reports is indicative of the use made of outlook information by farmers.

Budgeting in Wider Use

Budgeting as a method of shaping farm-production programs was brought into wider use. By this method, Federal and State extension workers draw up programs for typical farms with prospective receipts and expenses estimated and compared with similar figures for other programs. Thus farmers can decide what to grow, with increased understanding and confidence. Attention was given also to the forecasting of production trends over a period of years, as a basis for long-time farm programs. This work called for studies of the foreign production and the foreign consumption of hogs, wheat, cotton, and other crops much influenced by world conditions. Necessary data were obtained from the department's representatives in foreign countries, from the State Department's consular service, from the International Institute of Agriculture at Rome, and from foreign ministers of agriculture, and other official sources.

Additional facilities for gathering foreign information, however, would have been very useful. World competition in some agricultural products has increased in recent years. If the farmers of the United States are to work out definite long-time programs on a sound basis, they need much more information about conditions abroad than is at present available. Changing European production is vitally important in the hog market. In the wheat market, trends in foreign acreage are as significant as trends in acreage here. It is the same with cotton. When India increases its production of cotton, or consumers change their demand for various staples, the American grower needs to be quickly informed. A stronger foreign agricultural service, with specialized research workers, would greatly facilitate the department's efforts to help farmers in planning ahead.

Increased appropriations for reporting on fruit and vegetable crops enabled the department to issue new outlook reports dealing with these commodities last year. Several will be issued during the crop year 1929–30 on such special crops as early potatoes, lettuce, and canning crops. The extension services of Virginia, Maryland, and North Carolina are cooperating with the department in a special study of the early potato situation, which promises to have great practical value. Extensive publicity will be given to the department's intention-to-plant reports regarding potatoes. Arrangements have been made for cooperation with growers, producers, cooperative organizations, and national distributors in an effort to effect a better adjustment of the early potato acreage.

An Example in a Tobacco Area

How farmers may increase their income by adjusting their production to changing market conditions was recently demonstrated in the tobacco belt of Virginia. A few years ago farmers in this area produced dark tobacco of a type which faced a steadily declining export demand. Analysis of the market situation and of farm-management conditions on individual farms was made by representatives of this department in cooperation with the Virginia Polytechnic Institute. As a result, certain changes were recommended to the farmers concerned. Eight men who changed their operations accordingly increased their net earnings from less than $800 a year to more than $1,100. Four men ignored the recommendations, and the incomes of these men declined. This striking illustration of the practical value of economic studies combined with farm-management analysis impressed many near-by farmers and led to additional favorable changes in farm organization. Similar illustrations could be cited for other regions.

SHIPPING-POINT INSPECTION

Inspection of fruits and vegetables at shipping points increased by 18,367 cars during the last fiscal year, making a total inspection of fruits and vegetables of 266,831 cars. In addition, 5,202 cars were inspected at receiving points. Handlers and receivers of large quantities of fruits and vegetables, such as cold storage and express companies, made increased use of the inspection service, and inspection

for large terminal organizations grew rapidly. Inspection of dairy and poultry products increased slightly. Grading of hay and inspection of the graded shipments was made a regular service at 25 commercial points and 33 army posts, and the volume of the work increased materially. A seed-verification service, begun the previous year, covered the product of 60 commercial firms, and offered a valuable safeguard to purchasers of certain seeds. Use of the inspection service for soybeans by large crushers greatly increased. Demands for the classification of cotton increased also. The number of bales classified (exclusive of reviews) was 446,181 compared with 137,695 the previous year. Grain-inspection supervision was supplemented by a campaign to bring about a better understanding of the standards on the part of country grain dealers, and all previous records for the handling of appeals were broken. Grading and stamping of dressed beef was done in eight market centers, where 58,571 carcasses were graded and stamped.

MARKET-NEWS SERVICE

The market-news service was carried to several areas not previously reached. The southern circuit of the leased wire was extended to Montgomery, Ala.; Nashville, Tenn.; Jackson, Miss.; and New Orleans, La., where market-news offices were opened in cooperation with State agencies.

In the West a leased-wire drop was added at Sacramento, and in the Northwest the wire was extended to Portland and Corvallis, Oreg., Seattle and Spokane, Wash., and Boise, Idaho. In cooperation with several State agencies, distributing offices were opened to issue reports on the principal farm products of the several areas. Offices at Cleveland and Detroit were connected with the main line of the leased wire. With a few further extensions, the leased-wire service will carry the market news quite generally to the important markets and distributing points.

Statistical Charts Widely Used

As an aid to the States, the Bureau of Agricultural Economics prepared a series of over 100 charts presenting statistical data needed in local outlook meetings. These charts were issued in large wall-chart form. More than 3,000 copies were distributed for use by extension lecturers. Special chart books were also prepared as well as other literature to supplement the outlook statements. Economic publications designed particularly for extension workers were more used. Though these publications were trebled in number, the demand was not satisfied.

A recent survey showed that 287 research projects were under way in the Bureau of Agricultural Economics. Most of these concerned farm management and costs, statistical research, cooperative marketing, land economics, and agricultural finance and marketing.

Among the newer projects were a number relating to the analysis of the factors affecting the prices of wheat, corn, wool, butter, potatoes, tobacco, cattle, and fruits. This form of research is of primary importance in connection with outlook work and in the development of plans for marketing.

DEMAND FOR HIGHER-QUALITY PRODUCTS

Significant among recent developments in agricultural marketing is an increased demand for the higher-quality products. Such products bring higher premiums over ordinary or low-grade commodities than they formerly did. In fact, the lowest grades of some products are disappearing from the markets, as no longer worth handling. More general standardization and inspection of products have induced both producers and traders to pay more attention to quality. But the premiums offered for superior-quality goods in the central markets are not always reflected in the prices paid to the producers. Investigations to determine how this may be remedied are now under way in the department, and some practical developments have resulted.

Studies during the last year have sought to show precisely what determines good quality in different farm products, what qualities are in the greatest demand, and what quantities of the different grades are commonly produced. Some of the studies have followed products through market channels to the consumer. The distribution of peaches, prunes, honey, rice, and other commodities has been analyzed to reveal consumer preferences, and methods followed in the wholesale and retail markets have been observed. In this way a foundation has been laid for practical recommendations as to the production of better-quality goods. Farmers are not always rewarded in proportion to the effort they exert in the production of high-quality goods, but improvement in marketing methods and in knowledge of consumers' wants tends to bring about a more equitable reflection of quality differences in price differences.

Perhaps the best-known example of systematic effort to make country markets more sensitive to quality differences in farm products is the department's cotton grade and staple estimating work. The primary object of the grade and staple estimates is to indicate profitable opportunities for the production of better-quality cotton. Such opportunities depend of course on the degree to which quality production is encouraged by cash rewards. Farmers will not produce the kind of cotton demanded by the mills, even when they are in a position to do so, unless it pays them better to grow that kind of cotton than to grow any other kind. Heretofore the grower of superior fiber has often had to take a price no better than that received by his neighbor for inferior cotton. The department's grade and staple estimates should help eventually to overcome this drawback by facilitating the assembling of good cotton at country points in commercially significant quantities.

Premiums for Quality in Meat Animals

Studies of the value of meat animals, particularly cattle, are under way which will enable the department to advise livestock raisers regarding the most profitable types. For the year 1928 the average price of Choice and Prime steers at Chicago was $15.82 a hundred pounds. In the same season the average price for Common steers was only $10.76. The difference of $5.06 was purely an expression of quality difference. It does not follow of course that a similar

spread would prevail should the production of the better grades be relatively increased. However, room certainly exists for the profitable production of more choice cattle. The relative quantities of the various qualities of cattle that the market will absorb readily are being investigated to enable the department to advise farmers what type of animals to put in their feed lots.

Though increased egg production has been accompanied by a general decline in the level of egg prices during the last few years, each season has seen a better quality of eggs marketed. It has also seen a widening of the spread between the prices of good-quality and the prices of poor-quality eggs. Fresh eggs of the best quality sometimes sell in New York in the winter months for double the price of low-quality fresh eggs. However, the depressing effect of heavy low-grade production affects the prices of all eggs. The department is endeavoring to lessen this influence by encouraging the better handling and the closer grading of eggs at points of production.

More laboratory facilities for protein testing are required, so that the protein content of wheat may be more accurately reflected in prices at the farm. As is well known, the quality of wheat for milling depends largely on its protein content, and high-protein wheat is usually sold at a premium. It is therefore very important to measure protein content as a market factor. The testing must be done in well-equipped laboratories. Though private and commercial laboratories, and in some cases State laboratories, afford considerable service of this kind, the demand is not yet adequately met. A much more general testing of the crop for protein is necessary if the full value of the grain is to be reflected in the prices paid to the producers. It is therefore gratifying to report that Federal legislation to meet the situation has had favorable consideration in Congress.

LAND UTILIZATION

Much of the economic hardship suffered by farmers has been caused by too rapid expansion of the area devoted to farming. The eagerness of land-owning interests and selling agencies to induce farmers to occupy undeveloped areas, public encouragement to land settlement, and other influences have contributed to overrapid agricultural expansion in this country.

Our public-land laws and policies have favored expansion. Many millions of acres of Federal land in the Great Plains and intermountain regions were occupied in the years preceding 1921. Expansion through homesteading was brought practically to an end only by the virtual exhaustion of the supply of public land suitable for farming outside of areas requiring irrigation. The policy of the Government in exempting settlers on Federal reclamation projects from payment of interest on construction costs has also stimulated expansion.

Expansion has been misdirected as well as overstimulated. Additional crop land has been brought into use through drainage projects undertaken without due consideration of the comparative advantages, private and public, of reserving the areas as refuges for wild life. The drainage of marshes and shallow lakes has greatly reduced the area available to wild fowl for breeding, feeding, and resting, and

necessitated a Federal program to conserve marshland for migratory birds. Much inferior land has been occupied by settlers unfamiliar with local conditions and with the physical characteristics of the land, and unaware of the handicaps they were assuming. Some of these settlers have been overpersuaded to purchase tracts better suited at present to forest uses than to tillage. One of the major causes of the postwar depression in agriculture was previous over-expansion under the stimulus of war-time influence and of public and private land policies.

The remaining area physically capable of use for crops, but not at present so used, amounts to nearly a third of the total land area of the continental United States, and exceeds the area in harvested crops. This land is mainly of inferior quality. Much of it would require expensive clearing, drainage, irrigation, or soil improvement. It is mostly in private ownership. Though a large acreage is within the boundaries of existing farms, extensive holdings are owned by lumber or mining companies, railroads, and land companies. Since ownership involves outlay for taxes and other charges, many owners are impelled to promote the utilization of the land for farming. The desire of local communities and of local business interests for development reinforces the tendency to press the land into use.

Lands That Should Be Farmed

Lands not yet brought under cultivation but capable of making a good return on the development cost and a good permanent living for the farmer occupants should be farmed. To try to prevent it would be ill-advised. The urge to settle, and the community and private interest arrayed on the side of development, are bound to extend cultivation to new lands of this character. That the result may force lands elsewhere out of use is not a valid reason for opposing the new development.

The remedy for overextended agriculture is to curtail production, and the place to curtail is where returns are lowest. The problem is two-fold: To hold expansion in check where it would extend cultivation to marginal and submarginal lands, and to get lands of this character out of cultivation.

The per capita land requirements of the Nation for agricultural production are being reduced by the substitution of mechanical for animal power and by various economies in crop and livestock production. Furthermore, the rate of increase in our population is declining rapidly. A sound agricultural policy would help to prevent the waste of effort involved in the cultivation of farms where basic physical conditions or general economic conditions, or both, are unfavorable. Such a policy would seek to relieve the farming industry from the depressing effect of misdirected effort and misplaced farms.

Many farms that are now submarginal were established by hardy pioneers when agriculture was largely noncommercial. The passing of game and merchantable timber, the progress of soil erosion, the competition of commercial farming in the West, the attraction of other occupations, and the demands of higher living standards have made thousands of these farms obsolete. This condition is found particularly throughout much of the Appalachian region from Maine to Georgia, including the plateaus on the west, in the region

known as the Highland Rim, in the Ozarks, and in some of the western mountain areas. Some areas formerly adapted to commercial-crop production have sunk below the economic margin chiefly through soil depletion or erosion. A combination of soil deterioration and boll-weevil damage has made much land essentially submarginal in parts of the old Cotton Belt. In other areas, such as parts of the northern Lakes States and various parts of the Atlantic and Gulf coastal plains, relatively infertile lands have been occupied, the cultivation of which is not justified by present conditions.

In extensive areas that have become submarginal, gradual farm abandonment is taking place. Many farmers have abandoned their farms entirely, but there are various stages of abandonment. In many instances the practice of depending in part on outside income is virtually partial abandonment. In its most extreme form, farm abandonment becomes land abandonment. This stage is reached when present and anticipated returns from the land sink so low that no one considers it worth while to pay the taxes.

Abandonment Through Tax Delinquency

The abandonment of farms through tax delinquency is most serious in regions of extensive timber holdings which, following destructive lumbering and forest fires, are similarly becoming tax delinquent. As tax delinquency increases, the economic problems of the farmers who remain and of the local communities become more acute. Migration of the forest industries as the timber is cut out decreases the population, curtails the local market for farm products, diminishes local mercantile business, and causes a rising per capita cost for schools, roads, and other functions of government. As the forests wane, agricultural welfare is depressed, and farm abandonment tends to follow.

It is therefore clear that to discourage the occupation and cultivation of lands ill-adapted to farm operation should be part of a sound agricultural policy. But the task should not be thought of as primarily preventive. To attempt merely to restrict the use of land would be wrong. It would meet with inevitable resistance, since it would run counter to many interests and to the human desire to make use of land, and it would be economically unsound wherever the productive employment of land was possible. A constructive land policy is required. The task, while large and difficult, has great possibilities for the advancement of rural welfare. It should promote economic reorganization in the regions of extensive submarginal farm lands.

The three great forms of use to which all but an insignificant proportion of our land area can and must be put, if the land is used at all, are tillage, pasturage, and forests, including parks or wild-life refuges. It is necessary to determine, as nearly as possible, what lands are best suited to each of these uses or to their various combinations.

Forest use should be developed to make it a more efficient form of land use. Intelligent forest culture is required. A serious shortage of timber can be prevented only by extensive reforestation, particularly near the principal centers of consumption in the East and

South. Probably less than one-half our present forest area is satisfactorily stocked with growing timber of merchantable species. Even if all of the area of forest and cut-over land, approximately 470,000,000 acres, were growing timber under effective fire protection and intensive forest management, the annual growth would only about equal the present consumption.

Uncertainty as to Land Uses

More adequate reforestation is retarded by uncertainty as to the most economical utilization of particular areas. Much vagueness exists as to what lands might be economically farmed. It is not clear what lands could profitably be reforested by private enterprise and what lands will have to be reforested, if at all, by public agencies. The investigation necessary to settle these questions is highly complex, and usually requires facilities beyond the reach of the average landowner. Local interests generally lack the perspective needed to determine a policy of utilization consistent with national interest. Public action, such as changes in the tax system, is required to modify the basic conditions of land utilization in many localities.

These considerations point to the need for a public policy of economic land classification. This department has made several local land-utilization studies, mainly to test various methods of land classification. Several States have made inventories of their land resources. But more comprehensive land classification should be undertaken. Many aspects of the problem of promoting effective land utilization are national. Land classification on a national scale should be begun by the Federal Government, with the fullest possible participation and cooperation of the States.

The basis of such a classification would be definite information concerning the physical characteristics of various types of land. Physical and economic information thus assembled and organized would make it possible to determine whether areas of impoverished or decadent agriculture could be restored to prosperity by a reorganization of farming. For farming areas which could not be thus restored, the determination of the fact would indicate the true course to follow. It would also facilitate a program of regrouping population in sparsely settled areas so as to economize expenditures for schools, roads and other utilities. The economic possibilities of areas hitherto not employed for agriculture might also be determined.

Early Attack Essential

What can be done and should be done immediately is to recognize that there is a great problem of land use, that an early attack upon it is essential, that research is needed in diversified fields, and that it should be carried on systematically under a unified plan of coordinated action. Forest research, for example, should not be confined to study of the forest itself and of methods of managing and protecting forest lands so as to obtain the largest yields of forest products at lowest cost. Market requirements and possibilities are quite as important as management methods. The landowner needs to know what to grow as well as how to grow. New ways of utiliz-

ing forest products may open new requirements for raw material. Improved methods of manufacture may raise the value of stumpage. Economic and industrial studies are integrally a part of the program necessary for furthering right land use.

To determine the best form of use for lands of various classes and types, in all parts of the country, and the practices necessary to obtain from each class and type of land the highest yield of the most desirable kinds of products is a very large order. But in addition, sound, forward-looking public policies will have to be formulated and put into effect. It is impossible to do more now than suggest in a very general and fragmentary way, what an adequate public policy designed to promote efficient land utilization should include. Undoubtedly such a policy would make necessary substantial changes in taxation policies and methods. For example, present tax laws in many States are operating as a strong deterrent to reforestation on the part of private owners, and in some States have led to stripping the land of everything salable followed by abandonment through tax forfeiture. The public is thus saddled with responsibility for the land under conditions which make its restoration to productiveness a slow, difficult, and expensive process.

Again, public aid and encouragement to the adoption of desirable forms of land use, and to the adoption of methods that will make such use possible, will need to be extended through cooperative and educational activities. The public task will have to include extensive public ownership of lands that can be made to serve their higher purpose in no other way. Already there is extensive public ownership of this kind. It is partly Federal, partly State and municipal. Public ownership is necessary in order to (1) protect watersheds and prevent soil erosion, (2) conserve timber and grow forest crops, (3) provide for public recreational needs and preserve unspoiled for public enjoyment natural beauties and scenic resources, (4) determine and demonstrate to private owners methods of handling similar lands profitably without lowering or destroying their value, and (5) preserve and utilize forest-land resources that are not attractive to private investors. Public ownership for these purposes is being extended, and public sentiment seems to be in favor of doing still more.

Public Purchases of Submarginal Lands

There is marked interest in the possibility of aiding the stabilization of agriculture by public purchases of submarginal farm lands, with a view to their conversion to timber growing. Such purchases would no doubt be largely confined to mountainous timbered regions where a large percentage of land is already in woodland and the farms are largely limited to small patches of tillable soil, often rocky, frequently subject to erosion, and not adapted to cultivation with modern power-driven machinery.

A policy of submarginal land acquisition would aid in working out the problem of flood control. One of the reasons for establishing the western national forests was watershed protection. These forests, created from the public lands of the United States, cover the mountains of the region. In the East the Federal Government has been acquiring forest lands by purchase, primarily for watershed

protection, for nearly 20 years. The lands thus acquired are also mountain lands, protecting portions of the headwaters of a number of the principal navigable rivers. They are under administration as national forests. The total area acquired or approved for purchase from the passage of the Weeks law, in 1911, to the close of the fiscal year 1929, was 3,604,898 acres.

It is a great misfortune for the East that almost all its forest lands had passed into private ownership before the national-forest policy was inaugurated. Except in Arkansas, Florida, Minnesota, and Michigan, no considerable acreage of public domain forest lands was left that could be reserved and put under Federal administration. With some small scattered remnants of similar lands in other States, a total of 2,230,735 acres has been set aside for incorporation in the eastern national forests. The transfer of certain Federal lands that were being held for other purposes, and land acquisition through exchange have added 224,789 acres. Including lands acquired or in course of acquisition through purchase, the eastern national forests now contain 6,060,336 acres of Federal lands.

The States in the East own 5,000,000 acres of land that are either under public administration for forest and park purposes or are being held with a view to their administration or possibly their exchange as a means of blocking up administrative units. Virginia, North Carolina, and Tennessee are acquiring lands preparatory to their gift to the Federal Government for administration as the Shenandoah and Great Smoky Mountain National Parks, with a contemplated minimum area of 755,000 acres. County and town forests in the Eastern States approximate 500,000 acres. Yet all the publicly owned lands in the East that have been set aside or acquired with a view to their permanent public administration make up less than 4 per cent of the total eastern forest area. The public welfare requires a much greater percentage than this.

Public Ownership for Timber Production

The use of land for timber production as an alternative to nonuse is in large part the crux of the forestry problem in the East. In the belief that the self-interest of private owners could be relied upon to work out the most desirable form of use and to apply the methods that would make the land yield most, the Federal Government and the Eastern States alike long pursued policies of land disposal. Contrary to the early expectation, private ownership has brought a lowering of the productive value of large areas, and no small amount of actual land wreckage. When private ownership becomes no longer attractive, the land reverts to public ownership via tax forfeiture—an evil that will increase greatly unless public policies are altered. Even though the land remains in private hands, it may become and often has become a menace to the public welfare. The chances are that a substantial percentage of the 335,000,000 acres of privately owned forest land in the eastern half of the United States will eventually have to be acquired and administered as public-forest properties. National, State, and local community interests are all involved. All should share in the task; and unless all do energetically share in it, there can be no expectation of its satisfactory accomplishment.

The movement for county forests is a very recent development. It has important possibilities in some States. Town forests, too, are increasing rapidly in number; the oldest dates, it is said, only from 1914; yet several hundred are now in existence. While their purpose will for the present doubtless in most cases be primarily either to protect city water supplies and local scenic areas or to provide public recreation grounds, they may in time become increasingly the source of wood supplies harvested for revenue and a factor by no means negligible in bringing about the return to public ownership of a reasonably large acreage of the eastern forest lands. In Switzerland two-thirds of the forests are municipally owned. In this country, however, the major share of the task of public ownership will unquestionably have to be assumed by the States and the Nation.

States' Interest in Forestation

In some ways the States are more immediately concerned than is the Federal Government in preventing deforestation. The loss of property values and the decline in public revenues which exhaustion of the forest resource entails, if development of the land through other uses does not follow, affect most severely the localities and the States. Upon the States rests the responsibility to adopt land and forest policies to prevent their impoverishment through the vanishing of their timber resources. They have the police power necessary to restrict abusive practices and to prevent forest-land denudation; they have the power to adjust taxation so that it will not operate as a deterrent to timber growing; they have the power to take over and administer tax-delinquent lands; and they have a strong incentive to use these powers to prevent economic retrogression. But many of the States are wholly unable to assume the cost of acquiring and reforesting extensive areas of deforested land. This is true particularly in the States where forest destruction has been most general and reforestation is most urgent. The financial exigencies of such States or of their local political units are leading them to look with disfavor on any course that will tend to remove land from the tax rolls.

It is worthy of thought whether a program of Federal aid to States for the purchase and reforestation of lands by the States themselves would not prove valuable. The Federal-aid principle has been established in connection with the highway program and has proved a very stimulating influence in the construction of roads. A program of Federal aid to the States for forestry might prove equally valuable. All the resources now appropriated by the Federal Government for forest-land purchases must be employed in the prosecution of the program as outlined in existing laws. That program includes the purchase and administration of lands by the Federal Government for the promotion of timber production, as well as primarily for the protection of navigable streams. It is believed, however, that in the two forest regions of the East in which the greatest need exists—the Lake States and the South—purchases for the former purpose should be directed primarily to demonstrating the practices necessary for successful timber growing by other forest owners, private and public, and at keeping in pro-

duction forest lands which can be made to pay for protection and management only under Federal ownership. Through such activities examples will be set that should have a very powerful regional influence, and lands that would otherwise be a local liability may be made a local and national asset.

Policy of Federal Acquisition

The policy of Federal acquisition was established by the Weeks law, in 1911. Under this law purchases were limited to lands needing to be kept in forest for the protection of navigable streams. The law provided also, however, that the acquired lands should be permanently administered as national forests. The Clarke-McNary law broadened the purpose of acquisition to include specifically the promotion of timber production. The purposes of Congress, therefore, include not only the acquisition of lands needed for the protection of navigable streams and for continuous timber production to meet public requirements, but also the extension of national-forest administration, which aims at the coordinated development and use of all the forest resources, including recreational and wild-life resources; and beyond that, there is the purpose to aid in solving the forest problem of the United States.

So far, 36 separately designated units, situated in 17 States, and containing a gross area of 13,598,332 acres, have been approved as purchase areas by the National Forest Reservation Commission. Within these purchase areas the Federal Government now owns 6,060,336 acres. Of the remaining 7,537,996 acres, approximately 80 per cent, or 6,023,200 acres, eventually should be acquired. The National Forest Reservation Commission has indorsed a further program, formulated by the Forest Service, which contemplates the establishment of 23 new purchase areas with an approximate gross area of 3,035,000 acres, of which 90 per cent should be acquired.

On the basis of the past average cost of purchase, the full program will, if its completion is authorized by Congress, entail an expenditure of approximately $50,000,000. This purchase program does not anticipate such action as Congress eventually may take with reference to the establishment of forests as features of the Mississippi River flood-control program, or for agricultural relief through the withdrawal of marginal or submarginal lands from crop production, or for protecting the projected system of inland waterways, though some of the land included in the program is on the drainage of the Mississippi, and some of it is marginal or submarginal land hitherto cultivated, or which may be cultivated if not acquired for forest purposes.

Experienced Personnel Required

A minimum organization of skilled and experienced personnel must be maintained to handle acquisition work efficiently and economically. Urgent need exists for the enactment by Congress of a specific fiscal program and policy extending over a sufficient period of years to guarantee continuity and stability of plans and organization. This need was recognized in the original Weeks law, which not only authorized but made appropriations for a 5½-year period.

It was recognized again in the Woodruff-McNary bill, which as it passed the Senate authorized appropriations of $40,000,000 over a period of 10 years, and as finally enacted authorized appropriations of $8,000,000 over a period of three years. The Woodruff-McNary authorization will expire with the fiscal year 1931. Prior to its expiration a new fiscal plan and program is needed which will afford a basis for the future planning and prosecution of the purchase work.

SOIL EROSION

A problem urgently needing study in connection with the working out of efficient land use is soil erosion. That soil erosion is a national menace is now recognized. The appropriation by Congress of $160,000 for its study is an evidence of this recognition. The losses resulting from unrestrained erosion amount to many millions of dollars annually. There is evidence to indicate that the direct loss to the farmers of the Nation is at least $200,000,000.

The work of the Soil Survey of the Bureau of Chemistry and Soils, the investigations conducted by the Bureau of Public Roads, and the forestry and range-management studies carried out by the Forest Service have all served to indicate the wide extent to which the lands of the United States have been subjected to destructive erosion. A single county in the Piedmont section of South Carolina was found by actual survey to contain 90,000 acres of land formerly cultivated which has now been permanently ruined by erosion. In another county in the Atlantic coastal plain of Georgia, 60,000 acres of formerly fertile soil was found to have been washed and gullied beyond repair. In the brown-loam belt along the Mississippi River, many counties have been found to contain 10,000, 20,000, or 30,000 acres of land that have been ruined. Agriculture has been largely driven out of the uplands in this region by reason of destructive and unrestrained erosion. Also large areas of good alluvial land have in many cases been buried beneath infertile sands washed out of the upland gullies. Stream channels have become so choked with erosional débris that overflows have become exceedingly common, and large tracts of formerly productive soil are now being classed as swamp land.

The erosion problem has two aspects. One concerns the loss of soil fertility and soil material caused by the run-off. It is not the plant food alone that is removed by rain wash, but the solid soil material itself. The plant-food elements removed from the soil by growing crops can be restored in the form of fertilizers and manures, but the soil that is washed from the fields can not be restored except by natural processes that require centuries. When the mellow topsoil with its valuable humus and nitrogen is gone, there is exposed in its place the subsoil, which is less productive, less permeable, and less absorptive of rainfall. Usually this exposed material is heavier than the original soil, stiffer, and more difficult to plow.

Other Aspects of the Erosion Problem

The other aspect of the erosion problem concerns the consequences in the form of stream pollution, swifter run-off, and the eventual disposal of the soil and rock material carried away. Erosion causes

the silting of streams, reservoirs, and irrigation ditches, and the destruction or serious impairment of alluvial agricultural lands by overwash of sands and gravel.

This second aspect of the erosion problem makes it a part of the problem of flood control, in the solution of which forests have a place. Forests are one of the means of holding erosion in check. They are also a means of utilizing for timber production lands that have ceased to be cultivable through gullying or surface wash. Millions of acres both in the more hilly farming regions and in regions where the character of the soils makes for rapid erosion should be forested in the interest both of erosion control and of the best land utilization. It is in those parts of the East where rough and broken topography, steep slopes, thin soils, and to some extent high elevation make successful farming impracticable, except on limited areas with especially favorable conditions, that the maintenance of good forest cover is most urgently necessary from the standpoint of watershed protection and flood control for the country as a whole.

The present area of forest land in the United States is approximately 470,000,000 acres. On at least 75 per cent of this area the forest is a factor, often of paramount importance, in the prevention of erosion or the regulation of stream flow. On a very large additional area, probably aggregating as much as 50,000,000 acres, from which forests have been removed, erosion has become so serious that possibly the only practical remedial measure is reforestation. On at least three-fourths of the 100,000,000 to 150,000,000 acres of chaparral, woodland, and brush-covered areas, located primarily in the West, it is probable that either the erosion or stream regulation influences of the vegetative cover, or both, are a factor. Erosion from either water or wind is of some importance on probably 90 per cent of the area of untimbered range lands, and of serious importance on at least 50 per cent of this area. Such erosion is primarily the result of overgrazing or of unscientific grazing by domestic livestock.

The approach to the control of erosion and the regulation of stream flow on forest lands, both in research and in the practical application of remedial measures, must be through forest management, including fire control. In chaparral, woodland, brush, and range areas it must be through prevention of fires and regulation of grazing.

In the absence of specific appropriations for studies of erosion prior to 1928, various investigations have been carried on by the Forest Service, the Weather Bureau, the Bureau of Chemistry and Soils, and the Bureau of Public Roads, more or less independently and in connection with researches in closely related fields of inquiry. These studies have had to do chiefly with the relationship between forest, chaparral, or forage cover and stream regulation and erosion control in a particular region, and with the prevention of erosion by terracing and the construction of soil-saving dams.

Assembling of Data Necessary

Of first importance in the development of a comprehensive program for attacking the erosion problem is the assembling of all

available information in regard to the eroded areas in the United States, particularly their location and extent and the rainfall and other climatic data. For a number of years the Bureau of Chemistry and Soils, in connection with the soil-survey work, has accumulated information concerning the general location of the eroded land. During the past year this general information, the volume of which is large, has been supplemented by a rapid general reconnaissance survey. As a result of this work 18 distinct areas have been roughly outlined, and estimates have been made of the extent of erosion in these regions.

Public interest in soil erosion and moisture conservation led to the introduction on the floor of the House of Representatives of the following paragraph in the section making appropriations for the Bureau of Chemistry and Soils for the fiscal year 1930:

Soil-erosion investigations: To enable the Secretary of Agriculture to make investigations, not otherwise provided for, of the causes of soil erosion and the possibility of increasing the absorption of rainfall by the soil in the United States, and to devise means to be employed in the preservation of soil, the prevention or control of destructive erosion and the conservation of rainfall by terracing or other means, independently or in cooperation with other branches of the Government, State agencies, counties, farm organizations, associations of business men, individuals, $160,000, of which amount $40,000 shall be immediately available.

Since it was clearly the intent of the act that the problem should be attacked cooperatively by both Federal and State agencies, a committee, consisting of three representatives of the Department of Agriculture and two from State experiment stations, was appointed to formulate plans and recommendations for carrying out the provisions of the act. The provisional program worked out by the committee includes (1) continuation of the erosion reconnaissance survey of the United States and preparation of a map showing the extent and distribution of eroded areas; (2) a survey of the methods now used to control erosion and to conserve soil moisture; (3) laboratory studies of the physical and chemical properties of different soil types in relation to erosion; (4) field and laboratory studies of terraces, soil-saving dams, underdrains, and cultural methods to determine the most effective methods of preventing and controlling erosion and conserving soil moisture; and (5) field and laboratory studies of the effects of forest cover, chaparral brush, and range cover upon run-off, erosion, and stream-flow regulation and similar studies of remedial measures through forest management, fire control, and range management.

FOREST FIRES

One of the most formidable impediments to the development of wise use of our land area is forest fires. The loss of merchantable standing timber caused by fires is serious. Much more serious is the effect of fires on watersheds, the impairment and sometimes the complete destruction of soil fertility, and the deterrent results on the management of lands for timber growing. Repeated fires are the principal cause of forest denudation and the eventual abandonment of forest land as worthless. Were the fire factor eliminated, the upspringing of new growth and the maturing of trees

too small to cut when the first timber crop is removed would result in forest values that would generally make the owner wish to hold and take care of his land or would induce its purchase and use by some one else.

The Federal Government is cooperating with 38 States in maintaining protective systems. All the States with considerable forest areas, except Arkansas, have organized protection. The total area under protection, however, exclusive of the national forests is only seven-tenths the area needing protection, and the expenditures are less than half the amount estimated to be necessary for adequate protection of the entire area. Private owners contribute a varying part of the cost, in some States more than 60 per cent, in some States none.

The Clarke-McNary law authorized Federal cooperative participation in the maintenance of State protective systems up to a maximum of $2,500,000 annually. This maximum was set on the assumption that a total of $10,000,000 annually would be necessary for adequate protection of all the land that should be covered by the State systems, that an equal division of the cost between the public and the landowners is reasonable, and that the public contribution should be divided equally between the Nation and the States. Last year, however, the Federal Government contributed only a little more than half as much as the States. The financial situation of many of the States makes it very difficult for them to increase their expenditures materially, but an increase in the funds available for Federal allotment to them should serve, as it has served in the past, to hearten their efforts. The appropriation for the current fiscal year is $1,400,000 as against $1,200,000 for the fiscal year 1929.

Forest-Fire Protection Difficult

On the national forests, of course, the entire task of protection is assumed by the Federal Government. It is a task of peculiar difficulties. The West has, generally speaking, a long summer dry season. Inflammable surface vegetation and litter, coniferous timber, rough mountain country, sparse population, and inadequate means of transportation and communication all contribute to the danger of large conflagrations. The principal cause of fire is lightning, which is often without rain and which in electrical storms may start hundreds of fires almost simultaneously. The storms at times cover wide areas, reaching perhaps into two or three States. At other times they are purely local. In either case, if they start a great many fires burning at once, they impose a severe strain on the limited organization available to fight them.

With the summer of 1929 ended the twenty-fifth fire season since the national forests came under the Department of Agriculture. At the outset protection presented a superhuman task. The forests were largely unbroken, unmapped, and almost untrodden rugged wilderness. Parts of them could not even be reached by a pack train without days and even weeks of trail clearing and building. There was no equipment, no personnel trained in fire control, no experience, and little money available. The small handful of forest officers, each in charge of a very large area, fought the fires as best

they could, almost barehanded and with such help as they could pick up. Local sentiment was generally skeptical of the possibility of fire control and inclined to be indifferent to the need for it, if not hostile to the whole forest enterprise.

Fortunately the first five years went by before the protective organization was subjected to the test of the exceptionally bad fire season. Such seasons recur at irregular intervals. They are the result of a combination of unfavorable weather conditions, such as unusually protracted and severe drought, much lightning, and violent hot winds. The year 1910 brought the combination, with disastrous results. More than 4,900,000 acres of land within the national forests was burned over, with Government losses estimated at more than $26,500,000.

Never since has even one-fourth of this loss been sustained. Seasons of unusual, if not comparable, severity were 1917, 1919, 1924, and 1926. Each taught its lesson. The weaknesses and local failures of the defensive system were carefully studied and remedial measures devised. The technic of fire fighting, the organization necessary to gather, transport, equip, and maintain on the fire line large numbers of men, the provision of material, the creation of an efficient system of detection, and the construction of an extending system of protection improvements, such as lookout cabins and towers, roads and trails, telephone lines, and firebreaks—all these and many other things have been developed progressively. The tightening up and improvement of the whole system of control is still going on.

More Protection Improvements Necessary

The area burned over in the national forests during the five years from 1910 to 1914 averaged 0.75 per cent of the total area, from 1915 to 1919, 0.6 per cent, and from 1920 to 1924, 0.29 per cent. In the 4-year period from 1925 to 1928, the comparable figure was 0.28 per cent. The public value of the resources protected and the impairment of this value that results when the land burns over call for a development of the protective system to a substantially higher level of efficiency than has yet been attained. The greatest need is for a material increase in the protection improvements, with which the forests are at present very inadequately equipped.

A constructive and promising move has been made by the Chief Coordinator and the Bureau of the Budget for coordinating the various forest-protection activities of the Federal Government. The Chief Coordinator organized early in 1927 a forest-protection board, made up of the heads of the Weather Bureau, the National Park Service, the Office of Indian Affairs, the General Land Office, and the Forest Service, to formulate and recommend general policies and plans for the protection of the forests of the entire country. On November 23, 1928, the board was established as a coordinating agency by the Bureau of the Budget. The first report of the board presented to the Chief Coordinator its conclusions regarding the action necessary to coordinate the protection against forest fires given Federal lands by the several bureaus administering them and to carry out the cooperative policy laid down by the Clarke-McNary law for protecting other lands against fire. The board was continued, and its functions were broadened to include protection from insects, tree diseases, and

rodents, and the Chief of the Bureau of Biological Survey and representatives of the Bureaus of Entomology and Plant Industry were appointed by the Chief Coordinator as additional members.

The forest-protection board, acting under the direction of the Chief Coordinator and the Bureau of the Budget, has a broad field of usefulness. The objectives of coordination and cooperation that have been thus set up for the forest-protection work of the Government as a whole and the establishment of the board as a means for attaining them are eminently desirable. That this move will lead to more adequate, better-planned, more efficiently carried out, and more consistently correlated Federal forest protection can not be doubted. It creates a most valuable instrumentality for fiscal planning.

FOREST RESEARCH

The magnitude of the problem confronting forest research, involving practically every region in continental United States and an area practically equal to that of improved agricultural land, indicates the need for systematic, orderly development which can only be met by a national program covering some such period as a decade. The complexity of the problem, involving in the neighborhood of a thousand tree species and an extreme diversity of topographic, climatic, soil, and other conditions, emphasizes the need for such a program. The McSweeney-McNary Forest Research Act meets this need. An outstanding feature of this act is its recognition of the numerous phases of forest research and their intimate interrelationship—silviculture, or the production of forest crops; the protection of growing crops and their products against fire, insects, decay, and disease; the problems growing out of the interrelationship between forest trees and wild life; the possibility of producing forage crops on forest lands as a basis for a domestic livestock industry; the problems involved in the manufacture and effective utilization of wood and other forest products; and the economic questions that must be understood in developing public and private forest land policies. Economic research in forestry has a close affiliation with the research of the Bureau of Agricultural Economics in the field of agricultural-land utilization. The problem of livestock production on forest-range lands is one of the group of related problems. Two classes of field units are recognized by this act—regional forest experiment stations, at which is being concentrated the local work of the Forest Service and other bureaus in the department, and a national forest products laboratory, at which departmental investigations relating to forest products are being concentrated. The forest research act provides for a 10-year financial program.

Research along such lines, long one of the activities of the department, should be continued and expanded. Economic studies of timber supplies and requirements, forest taxation, forest insurance, and related problems are integrally a part of the program necessary for furthering right forest-land use.

Research will improve the effectiveness of fire protection in the national forests, and also on privately owned lands. The authority for such work is contained in the McSweeney-McNary Forest Research Act, but appropriations will be required.

MEDITERRANEAN FRUIT FLY

Early in April of this year the Mediterranean fruit fly, perhaps the worst fruit pest known, was found to be well established in central Florida. Appreciation of the far-reaching economic significance of this discovery was immediate and nation-wide. It resulted in a general demand that the eradication of the insect should be undertaken at whatever cost. Several States offered to detail personnel to aid in the work.

To determine the extent of the invasion, and to start work against the pest, an emergency fund of $50,000 was released by Florida and a transfer was made of $40,000 of funds appropriated to the Plant Quarantine and Control Administration of this department for other objects. All available forces—State and Federal—were thrown into the task of determining the spread of the pest, of destroying fruit in infested and surrounding orchards, and of spraying trees with poison bait. State and Federal quarantines were imposed and restrictions placed on the movement of all host fruits and vegetables. This action stopped the movement of such articles from infested areas and provided for their movement from other areas under adequate safeguards.

Congress on May 2, 1929, approved a request for authority to use not exceeding $4,250,000 of the unexpended balance of $5,000,000 appropriated in 1928 for pink-bollworm control. This action made it possible to undertake vigorous scouting to determine the spread of the fly, and permitted repeated spraying of infested groves and other groves near by.

How the Mediterranean fruit fly entered the United States is not definitely known. It is widely distributed throughout the world, and effort to prevent its entry has been continuous since the passage of the plant quarantine act of 1912. Quarantines have prohibited the importation of known host fruits and vegetables from countries where the fly is found. Inspection at United States ports has resulted in many interceptions of infested fruit. The forces available for such port inspection, however, have never been adequate.

The first surveys showed that the fly was thoroughly established in several orchards within the town limits of Orlando, Fla., and at a few outlying points not more than 6 miles north or south. Later investigations indicated that Orlando was the starting point of the invasion. No infestations equally intense were found elsewhere. The infestation as determined by scouting during the past summer has strengthened the belief that the pest was recently introduced, perhaps during the spring or summer of 1928. Its spread can easily be accounted for by the movement of citrus fruits last season. The intensity of the infestation in a few orchards in Orlando is accounted for by the insect's high rate of multiplication.

Fly Found in 980 Localities

The fruit fly has now been found in more than 980 localities in 20 counties within the central and northern part of the peninsular portion of Florida. The area surrounding these points of infestation which has been included in control operations involves two additional counties—altogether more than 8,100,000 acres. This area con-

tains approximately 67 per cent of the bearing citrus trees in Florida. It produced 76 per cent of the 3-year average of citrus fruit moved from the State. Scouting in other parts of Florida and in the States within the Cotton Belt has brought to light no field infestation outside of the area mentioned.

The fruit fly attacks practically all fruits, the only important exceptions so far determined being watermelons, pineapples, strawberries, lemons, and sour limes. The vegetables subject to its attack are peppers of all kinds, tomatoes, eggplants, and lima beans and broadbeans. Movement of fruits, except those noted above, and of the listed vegetables is restricted by regulations. In Florida the fly has shown a special liking for grapefruit and the sour orange, among the citrus fruits, although it can propagate in all citrus fruits other than the lemon and sour lime. Other freely attacked fruits commonly produced in Florida are the guava, the fig, the Surinam cherry, the avocado, the peach, and the pear. No restrictions have been placed on the movement of fruits and vegetables not known to be attacked.

Prior to August 1 more than 580,000 boxes of citrus fruit, 3,400 bushels of vegetables, and 7,100 bushels of noncitrus fruits were destroyed. Not all these host fruits and vegetables were actually infested. They were destroyed because they had been produced in infested properties or within 1 mile thereof. More than three-fourths of Florida's citrus fruit crop had been marketed before the fly was discovered. A large portion of the citrus fruit destroyed consisted of culls and drops that would have had no market value.

Created Starvation Period

The next step was to eliminate the flies remaining in the infested district and prevent their migration. It was decided to attempt this by creating during the summer a starvation period within the infested and protective zones. The plan involved the complete elimination of all host fruits and vegetables in a stage of growth attractive to the fly and the supplying, in lieu of normal food, of a sweetened poison bait. This method proved effective, and hope of eradicating the fly is largely centered on the method. But it necessitates the cooperation of every resident of the State and the acceptance of material sacrifices. If success is to be achieved, trees or shrubs ripening fruit during the starvation period must be grubbed up or cut down and the growth of host vegetables must be stopped. It is impracticable to remove ripening fruits and vegetables from the infested areas daily or weekly. To give up cherished yard or garden plants and commercial or other plantings in the interest of the citrus industry is a hard requirement, but one that seems absolutely necessary if the fruit fly is to be eliminated.

It became apparent early in June that to carry out an effective clean-up program and to provide for the removal of all host citrus fruits in the orchards within the infested area, would demand a heavy expenditure. Estimates indicated a total cost of $12,300,000 for the first quarter of the fiscal year 1930—July, August, and September, 1929—in which time most of the work would have to be completed. The cost of removing citrus fruit from the infested

zones was estimated at $6,300,000, and the cost of the clean-up and removal of noncitrus fruit in the protective zone at $6,000,000. In addition there were items for administrative and quarantine enforcement, inspection, the certification of products, and research. To meet these needs, which totaled approximately $15,500,000 for the fiscal year 1930, there was available a probable balance of $3,000,000 from the original appropriation, leaving a deficit of $11,500,000.

Expenditures on such a large scale can only be justified by a reasonable assurance that it is possible to eradicate the pest. But the menace to American agriculture would seem to warrant even greater expenditures if the desired end can be attained. The magnitude of the problem led the department to seek advice, both as to the work proposed and as to the possibility of conquering the fly, from a group of leading specialists selected from various parts of the country. In July I appointed a committee of experts consisting of Vernon Kellogg, secretary of the National Research Council, Washington, D. C.; H. A. Morgan, president of the University of Tennessee; T. P. Cooper, dean of the College of Agriculture of the University of Kentucky; Victor R. Gardner, director of the Michigan State Experiment Station; T. P. Headlee, State entomologist of New Jersey; G. A. Dean, head of the department of entomology at the Kansas State Agricultural College; and H. J. Quayle, professor of entomology at the University of California.

These specialists reported that eradication of the pest was not only practicable but an economic necessity. They recommended enlargement of the work under way and modification of the quarantine regulations so as to permit, under a system of sterilization, the interstate movement of citrus fruits from areas which previously had been considered infested. Research in this department had indicated the practicability of control of the larvæ and eggs in the fruit either by refrigerating the fruit to 28° F. or by heating it to some 110°. The committee stated that the sterilization of whole fruit could, in their judgment, be accepted as a substitute for the destruction of the mature crop in the formerly infested areas and would obviate the necessity of removing all citrus and other fruit of the coming crop. The department adopted the committee's report, and revised the fruit-fly quarantine and regulations so as to carry out the program recommended.

Substantial Appropriations Necessary

It is certain that in addition to the funds now available substantial appropriations will be needed to carry out the enlarged program for the remainder of the present fiscal year. Steps have been taken for the presentation to Congress of an emergency item, for the same objects specified in the initial appropriation of $4,250,000. Since it was essential that the program should be started at once, by reallotment I made available to the first quarter of this fiscal year $2,175,000 of the unexpended balance of the funds appropriated for the fight against the fruit fly.

The estimate of necessary Federal expenditures does not include those phases of the work that may possibly be done by the citizens of Florida, such as the eradication of minor hosts, and spraying and clean-up work in commercial and private orchards.

The costs incident to those phases of eradication which relate to production and handling and marketing of commercial crops are to be borne by the growers and the shippers. Certain phases of the work, however, can not be thus delegated. Accordingly the estimate provides that the Federal Government, in cooperation with the State, shall be responsible for (1) supervision of the spraying and clean-up done by owners, (2) the clean-up of wild and noncommercial lands, abandoned properties, etc., (3) the spraying of roadsides, town properties, and wild land, (4) the scouting necessary throughout Florida and other States, (5) the certification of products, (6) the supervision of sterilization, and (7) the enforcement of quarantine regulations.

I have already indicated that, prior to the discovery of the establishment of the Mediterranean fruit fly in Florida, the bulk of the 1928 crop had moved out of the State through normal channels of distribution and diversion, thus carrying the risk of spreading the pest widely. The danger to the Southern States was especially great, particularly as much of the movement was by autotruck, and included lower-grade fruit specially open to the possibility of being infested. The more western States had also been reached by bulk carload shipments of low-grade fruit.

All States concerned were notified of this risk in April, and an immediate inspection was begun by State forces of all Florida citrus fruit within their borders. An interstate conference held at Atlanta on May 16 resulted in more intensive and concerted action. Financial aid was given by the department out of the special fruit-fly appropriation. The State extension services throughout the Cotton Belt States from Texas to Oklahoma eastward were enlisted in the effort to locate and inspect all Florida citrus fruit within these States. This was of tremendous service. The immediate result was the discovery and destruction of 11 shipments of infested fruit distributed in Arkansas, Georgia, Louisiana, North Carolina, and Texas. Instances of infestation were reported from New York and Ohio. Most of the fruit which had moved into these States had been consumed, and the gravity of the situation was further modified by the absence of ripening host fruits at that period in these States. Immediate controls were placed on bulk shipments in April by Georgia and Alabama. This action practically excluded further truck movements from Florida.

Restriction of Shipments

In recognition of the uncertainty as to the extent of the spread of the pest in Florida and as a further protection to other States, Federal action on May 16 eliminated all movement of host fruit and vegetables from Florida into 18 Southern and Western States. This restricted the movement of Florida host fruits and vegetables to destinations in Northern States. Within the Northern States additional restrictions limited the movement of fruit from protective zones to a group of Northeastern States most removed from risk of infestation. A subsequent amendment to the quarantine prohibited reshipment of host fruits and vegetables originating in Florida out of the district into which the original movement was authorized.

Inspection in the Southern States was followed up by surveys throughout the summer covering the peach season in Georgia and Alabama, and generally the fruit season in all these States from Texas eastward, for the purpose of determining whether there had been any local establishment of this pest. It is gratifying to report that so far there is no indication of the establishment of the fruit fly beyond the area designated in central Florida.

The Mediterranean fruit fly has introduced the question of expenditures for its control and eradication on a greater scale than has been contemplated for any other insect pest. The expenditure of $10,000,000 in the corn-borer campaign is the nearest approach. But in that case there was no thought of eradication. It was intended mainly to demonstrate, over parts of five States, that control of the borer was practicable by modification of farm practice. In the case of the fruit fly, the object is eradication. No one who realizes the menace of this fly to our fruit and vegetable industry will question that its eradication is worth any reasonable expenditure. In determining Federal policy in the eradication effort a long look ahead is necessary. Expert opinion has been rendered that eradication is possible. The department would seem to be fully justified in accepting this decision.

The possibility of eradicating the pest is strengthened by the results of the clean-up and spraying work so far carried out in Florida. Fly abundance and fruit infestation have been rapidly diminished, and new records of finding infested fruit and flies have become very few. In fact, for a considerable period there have been no such findings. This does not mean that success is in sight. All methods of discovery applied over such a vast area must naturally be looked upon as only partially effective. It does indicate, however, that control of the pest can be made very effective and gives hope that eradication is not impossible.

Research Work Instituted

Fruit-fly research work was instituted in Florida by the Bureau of Entomology in cooperation with the Plant Quarantine and Control Administration. This work was greatly expanded under the special fruit-fly appropriation. There is need for a further increase in this field. The results so far of immediate service have been (1) the development of a more effective type of poisoned spray to kill the adult flies in orchards, (2) the development of attractants to facilitate the collection of adult flies in orchards or elsewhere to determine presence or spread of the pest, and (3) the development of a fumigant with which to kill adult flies in motor and railway cars, buildings, or other premises.

Another important phase of research is the determination of methods for sterilizing fruit by refrigeration or heat. The department's discoveries in this field should make it possible to utilize, either by movement in commerce or in some type of processing, all fruit not actually infested. Methods have been devised for the disposal of waste and cull fruit, both in bulk from the orchards and as a continuing process in connection with packing houses. Machinery for this purpose has been devised. Methods for bulk disposal were immediately put in use, and greatly facilitated the disposal of the

infested fruit of the crop of 1928–29. Determinations made by the department as to the host relationships of fruits and vegetables in Florida were at once translated into quarantine restrictions or made the basis for the release of articles from quarantine.

EUROPEAN CORN BORER

There was no important change in the European corn-borer situation during the season of 1929. In the New England area there was a slight general increase in abundance, but serious commercial damage occurred, as in 1928, only in a limited district in Rhode Island and in adjacent Massachusetts. In this district, however, there was a notable decrease from 1928 in the abundance of the borer, due to the clean-up of cornstalks by farmers. In 1928 this area in Rhode Island showed an average of 876 larvæ per hundred plants, whereas in 1929, under clean-up methods, the number was reduced to 249. The adjacent area in Massachusetts in 1928 showed 654 larvæ per hundred plants, compared with 230 for 1929.

In the western area, in 1929, the season in general was unfavorable to the borer, there being only a slight increase in its abundance In Michigan there was a decrease. Commercial damage in the western area occurred only in a few small fields along Lake Erie, chiefly in Lucas County, Ohio. Taking this area as a whole, the average number of borers per hundred stalks was 6.65 for 1928 and 7.78 for 1929; in other words, an average of 1 borer to 15 plants. To appreciate the significance of borer population based on the number of larvæ per hundred stalks, it should be noted that the beginning of commercial injury requires from 400 to 500 borers to 100 stalks, or an average of 4 or 5 borers per stalk. Except for the infestation in Massachusetts and Rhode Island, none of these figures indicate even an approach to crop losses. Taken as a whole, the record of the corn borer in the United States still leaves its future economic importance open to question. However, the heavy damage it occasioned over a few years in a limited district in Ontario now largely controlled by better farm methods and the fairly heavy initial damage in a limited district in Massachusetts are indications of the possible menace of this pest to our corn crop. This menace would seem to warrant the control methods which are now enforced to delay its spread, which must continue and which will eventually carry the insect into the main Corn Belt.

Natural Spread of the Borer

The natural spread of the corn borer by flight during the 1929 season was normal, namely, between 20 and 30 miles. Its long-distance carriage and establishment seem to have been substantially prevented by quarantines, notably road controls to prevent the carriage of green or sweet corn out of the infested area.

At 226 road and ferry stations 11,557,755 vehicles were inspected, and 342,772 ears of sweet corn and about 70,000 miscellaneous restricted articles were intercepted. From these some 2,430 borers were taken. All the confiscated material was destroyed or returned to its point of origin. In general, truckers, who normally transport the bulk of corn or similar products, are familiar with the quaran-

tine and cooperate in its enforcement. Between 90 and 95 per cent of the interceptions were made from passenger vehicles with motorists unfamiliar with the quarantine. Cooperation by such motorists has been good. Out of 11,000,000 motorists hailed, less than 1,000 refused to stop.

To detect any outlying points of spread, the States surrounding the corn-borer area are surveyed each fall, particularly along the main lines of motor travel. This survey in 1929 disclosed two fairly distant points of infestation, one in Kentucky on the Ohio River (Oldham County), the other in the southern point of Ohio (Gallia County), also on the Ohio River. Three outlying points were determined in northern New Jersey. These outlying points will be cleaned up in accordance with the previous practice, which in many cases has been successful. In the New England area, a considerable spread eastward along the coast in Maine was determined. There was a gradual approximation of the eastern and the western areas in Connecticut, Massachusetts, and Vermont.

PINK BOLLWORM OF COTTON

The big outbreak in 1927 of the pink bollworm of cotton in seven counties in west Texas, which was determined during the first three months of 1928, and which involved scattered infestation of nearly 400,000 acres of cotton land, seems to have been practically suppressed. Only a single infestation was found in connection with the 1928 crop, and that consisted of only a few bolls in a field near Odessa. This favorable result can be accredited to an intensive clean-up of the entire section, which was made possible by a special emergency allotment of $400,000, and to the fact that conditions during the winter of 1927–28 were unfavorable to the survival of the hibernating larvæ. Similarly unfavorable weather conditions were indicated by the reduction almost to the zero point of the pink bollworm in portions of Arizona and New Mexico, and in the El Paso Valley of Texas. Provision was made by Congress in a joint resolution of May 21, 1928, for the establishment of a noncotton zone, particularly in the seven counties in west Texas referred to, but verbal changes in the appropriation item at the last moment made this money unavailable for use in these seven counties. Enforcement of a noncotton zone, in connection with the favorable winter and clean-up operations which were carried out, would probably have completed the eradication.

The only portion of west Texas which was covered by a noncotton zone was Brewster County. The cotton area of this county is on the Rio Grande in the extreme point of the Big Bend district, and the heaviest infestation occurring at any point in the United States has been in this county. The results of the clean-up and noncotton zone for a single year will be reflected on the crop of the present year, data concerning which are not yet available. The main idea in establishing a noncotton zone in Brewster County was to eliminate the possibility of spread by flight from that region to west Texas and New Mexico. The entire cotton area along the Rio Grande from the Big Bend to El Paso is in contact with Mexican cotton fields and therefore subject to reinfestation annually, a condition

which makes it impracticable to undertake any drastic eradication measures until Mexico can cooperate so that the cotton areas on both sides of the boundary can be cleaned up at the same time. All the areas in west Texas, New Mexico, and Arizona which are still invaded by this pest are under quarantine restrictions requiring the disinfection of the cottonseed at gins, fumigation and compression of lint and linters, supervision of oil mills, and the maintenance of road stations to prevent untreated material from being taken out of the infested areas. These precautions seem to have been effective in preventing spread of the insect to new locations.

GIPSY MOTH

Gipsy-moth infestation in New England, as measured by the acreage of woodlands defoliated, was much more severe in the summer of 1928 than it had been for many years, and the outlook is that the extent of the injury will continue to increase. More than 262,000 acres of forest land were stripped by the pest last year, and a greater acreage of defoliation was found in the summer of 1929.

The spread of this insect to the west is kept under control by the maintenance of a barrier zone about 25 miles wide extending along the eastern boundary of New York State from Canada to Long Island Sound and bounded on the west by the Hudson River. Intensive eradication measures are employed to stamp out all gipsy-moth outbreaks within that strip of territory. The number of infested locations in the barrier zone increased sharply in 1928, more than double that of the previous year. The worst part of the area was in southwestern Massachusetts and northwestern Connecticut and the adjoining portion of New York State, and was caused by spread from moth colonies east of the zone. All these new points in the zone were treated and sprayed; but since many were located in woodland, more intensive scouting of the large forest areas in the zone will be required. The department feels that the inspection of a belt of territory east of the zone and the treatment of all large infestations there is vitally necessary in order to prevent constant reinfestation of the territory that has been cleaned. To undertake such work will require a very substantial increase in this appropriation item.

More Satisfactory Conditions in New Jersey

In New Jersey, where an effort to eradicate completely an outbreak discovered in 1920 has been in progress, the situation is very much more satisfactory. No gipsy-moth infestations were discovered in the State during the last fiscal year except one small colony. The area infested when the pest was discovered in New Jersey nine years ago covered more than 200 square miles, and scouting revealed about 3,000,000 egg masses. The eradication plan adopted at that time by the Federal Government in cooperation with the State provided for the extermination of the pest by means of scouting the infested section and the territory surrounding it, the treatment of all egg clusters of the insect, and extensive spraying operations. This is the largest extermination campaign ever attempted against a forest insect of this type, and the excellent prog-

ress made is highly gratifying. The volume of work required has been gradually reduced, and the completion of the project in New Jersey is expected within the next few years.

Long-distance spread of the insect by the shipment of woody plants and forest and quarry products has been prevented by the enforcement of Federal quarantine regulations requiring the inspection of such products before their movement is allowed. During the past fiscal year 369,044 shipments forwarded to all parts of the United States and Canada were inspected, and 143,484 shipments that had been processed or stored in such a manner that infestation could not be transmitted were moved on permits provided for by the quarantine regulations. On the material offered for shipment, 1,782 clusters or larvæ of the gipsy moth were found. Before movement was allowed the infested material was cleaned.

The discovery and stamping out of many small colonies in this barrier zone, reinforced by the inspection of products to be shipped from the infested territory, have protected all sections of the United States from the permanent establishment of this pest, at expenditures which are small in comparison with the continuous losses that have been prevented.

JAPANESE BEETLE

Since the promulgation of the first Japanese-beetle quarantine in 1919, the area under regulation on account of this insect has increased from 48 square miles to 21,353 square miles, and now includes New Jersey, the District of Columbia, eastern Pennsylvania, northern Delaware, and small portions of Connecticut, New York, Maryland, and Virginia. The most isolated point of known infestation is 192 miles by air line from the center of the heavily infested area. Despite this apparently enormous increase in area, the annual spread by normal flight of the beetle of from 10 to 15 miles over a period of 11 years is largely responsible for the present distribution. The quarantine which is being enforced on account of the Japanese beetle has as its principal purpose the prevention of long-distance spread of this pest through the movement of nursery stock and farm and garden products. This purpose seems to have been fully achieved.

There is, however, in addition to local spread by flight, another type of movement which it is impracticable to attempt to control in view of the congested population in the area now reached by the beetle. This is accidental carriage by motor or train movement through the Japanese-beetle area during the period of beetle abundance. A number of isolated points of spread have been determined during the last two years which are believed to have resulted from such accidental carriage by motor or train. Most of these points, determined in 1927 and 1928, are within 50 or, at the outmost, 100 miles of general Japanese beetle infestation. With respect to such points, the department has approved the policy of treating them as separate control units rather than including them by a broad extension of the quarantine lines in the general quarantined area. This mode of treatment necessitates cooperation by the States concerned, and it is in accord with policies which hitherto have been followed in connection with other plant quarantines; namely, such quarantines as those on account of the gipsy moth, the corn borer,

and the pink bollworm. To include such isolated points under the general quarantine would immediately open extensive areas in the States concerned to the uncontrolled movement of nursery stock and farm products, with the result of establishing the beetle more or less quickly throughout such areas.

Results from Beetle Traps

The use of beetle traps at Baltimore, Washington, and in Alexandria County, Va., has resulted in the collection of great numbers of beetles. The possibility of substantial control at such isolated points by this method will thus be given a fair demonstration this year. That enormous quantities of beetles can be collected by the trapping method has been fully demonstrated. In fact, on a single property in New Jersey nearly a ton of beetles were thus collected during the current season. In the generally infested areas, however, such trapping is of little value, even in instances like the one cited, unless the employment of this method is general. Otherwise the placing of numbers of traps on individual properties will have the unfortunate effect of attracting enormous numbers of beetles to such properties from adjacent land. This objection, however, does not apply to isolated points.

The new outlying points at which the Japanese beetle has been found during the present summer include Boston, Mass., Providence, R. I., and Norfolk and Cape Charles, Va. It seems reasonable to infer that the beetle reached these places by the movement of boats from Philadelphia during the height of the season, aided possibly also by accidental railway carriage.

Within the present area regulated on account of the Japanese beetle there are over 4,000 nursery and greenhouse establishments. These comprise the principal and most extensive nursery operations in the country. More than 1,000 of these regularly ship quarantined nursery and ornamental stock from the restricted zone to all parts of the United States and various foreign countries. The enforcement of the quarantine regulations has accordingly grown to considerable magnitude, involving the yearly certification for interstate movement of 73,000,000 plants. To avoid risk of such plants being the means of long-distance carriage of the beetles in the larval stage, plants from nurseries determined as infested are either required to be shipped free from soil, or soil balls with the plants are given a chemical treatment which, without injuring the plants, will destroy the larvae. Under one or the other of these conditions all types of plants are permitted movement from infected nurseries or districts. In addition, the effective enforcement of the quarantine requires the supervision of shipment of thousands of carloads of sand, soil, peat, and manure.

Asiatic-Beetle Distribution

The present distribution of the Asiatic beetle covers a considerable area in northern New Jersey and the southern point of New York, with outlying points of infestation, respectively, at Albany, N. Y. (a determination of this year), New Haven, Conn., Harrisburg, Pa., and the District of Columbia. These beetles are somewhat closely re-

lated to the Japanese beetle and correspond also with the latter more or less in larval and adult habits. The economic importance of these beetles is largely, however, in their capacity to injure and destroy lawns and grasslands. This is particularly true of the so-called Asiatic beetle, but also applies to the Asiatic garden beetle, which latter, however, is, in the adult stage, an active leaf feeder and attacks a large range of ornamental and crop plants. The Asiatic beetle has demonstrated, at points where it has gained a foothold, a capacity to destroy lawns beyond that of the Japanese beetle or any of our native species. In New Haven, according to the State entomologist, upwards of $100,000 has been spent in a few years for the replacement of lawns destroyed by the Asiatic beetle in an area of infestation comprising only a small section of that city. Both of these beetles have invaded important nursery districts; and quarantine restrictions are especially necessary, therefore, to prevent their distribution widely in the United States with plants shipped with untreated soil. This need is emphasized by the fact that large numbers of the white grub of this insect, in which stage it passes the fall, winter, and spring, have been found in earthballs about plants coming from infested premises.

The research work which has been conducted with respect to these beetles has developed means of disinfecting the soil which must go with certain types of nursery stock, and the movement of all nursery stock is provided for either under such treatment or when freed from soil. Local and other grasslands can also be protected from these bettles by arsenical poisoning, but this is a very expensive treatment which must be repeated at intervals.

RESEARCH IN ENTOMOLOGY

Research carried on by the Bureau of Entomology in connection with the newly imported pests of major importance discussed in the foregoing pages in regard to biological, environmental, and host relationships has gone hand in hand with the control and eradication efforts, and the results of this research form the substantial basis for such efforts. This research has covered every relationship of the insect to the plant and to farm practice, including the development of special types of farm or other machinery to make control inexpensive and possible by means in line with ordinary farm practice. It has covered also all the means of repression by use of poisons, gases, traps, etc., and has included the importation of natural enemies from the foreign countries of origin of these pests and the establishment of these natural-control aids here. This latter field is one of the greatest interest and importance because it eventually should bring about in this country the balance which exists in the countries of origin and which in most cases greatly limits the losses due to these pests or makes their recurrence infrequent. In the case of the corn borer, the Japanese beetle, and the gipsy moth particular effort in this direction has been made, and many thousands of parasites of different types have been introduced, and many of these have been successfully established. The beneficial results from such establishment are now beginning to show in the reduction of damage in the older and originally the most heavily infested centers.

UTILIZING FARM BY-PRODUCTS

Increased attention has been given by the department in the last year to the problem of utilizing agricultural by-products. In gross tonnage by-products constitute more than 60 per cent of the material annually produced from the soil. Though industrial uses have been found for some of this material, much further progress in this direction seems possible.

The principal farm by-products are cornstalks, corncobs, cereal straw, oat hulls, cotton stalks, cottonseed hulls, flax straw, peanut shells, and sugarcane bagasse. These materials are of course not wholly wasted at present. Their value as feed for livestock or as fertilizer is considerable. The industrial utilization of farm by-products is economically sound only when the prices paid for them to the farmer represent a greater value to him than the by-products would have if left on the farm. It has been demonstrated, for example, that on some soils under specially favorable conditions a ton of cornstalks, when plowed under, may have a fertilizer value of from $5 to $6.

In considering the commercial advantage of selling cornstalks the farmer must reckon the cost of buying, hauling, and applying the fertilizer which would be necessary to replace the stalks. He should also include a reasonable profit for the extra effort required. Chemical science and economic development may eventually make cornstalks and similar farm by-products worth more as cash crops than they are as feed or fertilizer. Meantime, the necessity of meeting this requirement should not be forgotten. The prospect that it may eventually be met with an ample margin, on a considerable part of our farm by-product output, is suggested by the progress already made.

Cull fruits and vegetables constitute a heavy annual waste. Sweetpotatoes alone, it is estimated, are culled to the extent of 20,000,000 bushels annually and potato culls amount to 76,000,000 bushels a year. Cull apples probably average 35,000,000 bushels annually, and similar large wastage of other fruits and vegetables takes place. Scientific and industrial progress which permits the utilization of these by-products constitutes at once a strong influence for agricultural improvement and an important means of conserving the Nation's resources. It is gratifying to be able to report, therefore, that experiments in the department have found economic uses for some crop materials formerly wasted and have laid a foundation for future economies of the same nature. A brief recital of what has been accomplished and some reference to the more promising of the investigations now under way should be of interest.

Farm Wastes Classified

Farm wastes may be classified under three main heads—namely, crop by-products, unsalable crop surpluses, and by-products of industrial operations upon agricultural raw materials. In the first group are included hulls, cobs, stalks, straws, etc. In the second are culled fruits and vegetables; and in the third, products that, while not without utility, may lack a profitable market. Chemical

research combined with a study of economic problems is the key to the utilization of these wastes. It is of course obvious that the problem of utilizing farm by-products is not merely a matter of discovering means of turning them into usable materials. It is also necessary to determine whether this can be done profitably, when full allowance is made for gathering, transportation, storage, and other costs. It is not sufficient, for example, to develop a process for making paper or fiber board from straw or cornstalks. Means must be found for doing so at a cost that will enable the product to compete with paper or fiber board manufactured from other materials. Thus the problem is twofold—(1) chemical, and (2) economic. The economic phase of the problem may require much practical experimentation, perhaps during many years, and may possibly also involve large-scale production. Industrial operations that are uneconomic on a small scale may be profitable on a large one.

Important results have been obtained from studies of the utilization of the cellular materials of crop by-products. These materials consist chiefly of cellulose, lignin, and carbohydrates. Dry cornstalks, for example, consist of approximately 36 per cent cellulose, 30 per cent lignin, and 27 per cent carbohydrates. Cellulose is the fibrous part of the plants and represents about one-third of the dry matter of vegetation.

As far back as 1908 mill-scale experiments were conducted by the department in making paper from the cellulose of farm by-products, especially cornstalks, broomcorn, sugarcane bagasse, rye straw, cotton-hull fiber, cotton stalks, flax straw, hemp hurds, etc. These investigations showed that excellent white paper can be made from bagasse, straw, and cornstalks. One commercial mill is now making insulation board from wheat straw, and two others are developing processes for manufacturing board from cornstalks. Another mill is producing bleached pulp from cornstalks. These industrial enterprises resulted largely from early scientific investigations conducted in the department and by other interests, and may eventually open up important new markets for the cellulose contained in crop by-products.

Experiments on Commercial Scale

The practicability of using by-products from farm crops for paper making on a commercial scale has not yet been fully demonstrated, though encouraging experiments are under way. Fiber board is produced profitably from sugarcane bagasse. Under certain conditions unbleached wrapping paper and board may be produced profitably from straw. Approximately 500,000 tons of straw were used for this purpose in 1927. Insulation board is now made commercially from straw and cornstalks, as well as from bagasse. Cellulose from wood is now the chief raw material for paper, fiber board, insulation board, etc., but our wood supply is decreasing at a rate which indicates that other raw materials for paper and board making will eventually be in demand.

Important results have been obtained by the department in the distillation of straw and similar by-products. In tests made at a

full-size gas-producing unit on the department's farm at Arlington, Va., it was demonstrated that gas produced from straw may be used for lighting and heating and as a motor fuel. As yet this can not be done profitably on the individual farm. Commercial experiments, however, have indicated that this work may eventually have significant industrial consequences. An inviting field is the production of alcohol and acids from cellulose wastes. Investigations in this country and Europe have shown that alcohol, acetic acid, and acetone may be produced from straw and similar materials.

Research on lignin in the department has yielded results of exceptional significance. Lignin constitutes from 20 to 30 per cent of the dry material found in hulls, straw, and leaves. It is a complex material with many industrial potentialities, possibly equaling those brought to light a century ago by experiments with coal tar. The Department of Agriculture has utilized lignin in making varnishes, dyestuffs, and various aromatic chemicals. It has produced synthetic resins by combining lignin with aromatic amines and has obtained acetone, methanol, acetic acid, guaiacol, and eugenol from lignin. Research work on furfural in the department has led to the commercial production of this chemical compound at prices only a fraction of those prevailing before the work was started.

Furfural is a liquid obtained by the action of steam and acid on pentosans, an important carbohydrate constituent of some crop by-products. It is commercially used as a substitute for formaldehyde in the preparation of artificial resins of the Bakelite type, and also as a solvent, a purifier of rosin and anthracene, a paint and varnish remover, an intermediate in the production of dyes, a repellent for the blowfly, and a possible intermediate chemical in the production of pyromucic acid. It is being made commercially from oat hulls and is reported to be selling in tank-car lots at from 10 to 12 cents a pound. This price may be compared with $30 a pound in 1918, when the department's furfural research work began. In producing furfural from oat hulls, corncobs, and other farm wastes certain by-products are elaborated which can be used in making corrugated-fiber containers and in the productin of coal briquettes. As yet utilization of these by-products is in only the development stage.

New Uses for Sweetpotatoes

Investigations are under way in the department in the technology of converting sweetpotatoes into commercial products. In some seasons a large part of the sweetpotato crop is classed as cull and finds no profitable market. Approximately 20 per cent of the crop may be too large or too small, or unmarketable for some other reason. In addition, surplus sweetpotatoes are often a problem. When growing conditions are exceptionally favorable the yield from a normal acreage may exceed the demand. Semicommercial experiments are now being conducted in the manufacture of starch from sweetpotatoes at the department's Arlington Experiment Farm. Excellent starch has been made in this way and commercial methods of manufacture are being developed. A commercial sweetpotato starch plant has been erected in Louisiana. Sweetpotato starch may possibly prove an acceptable substitute for tapioca and sago starch,

the raw product from which high-grade dextrin and adhesives for postage stamps and envelopes are made. This country imported about 116,000,000 pounds of tapioca and sago products in 1927. If starch from sweetpotatoes can be substituted for starch from imported tapioca and sago, the demand for sweetpotatoes should be increased by some 18,000,000 bushels. Dried sweetpotato flour is also valuable in bread making. Heretofore unmarketable sweetpotatoes have been largely fed to hogs. Compared with other root crops, they are rich in the proteins essential for growth and nutrition, and are valuable as a supplementary feed.

Overproduction of potatoes is frequent enough to indicate the urgent necessity of industrial utilization of the surplus. Overproduction, however, tends to alternate with underproduction, so that industrial concerns utilizing potatoes might not be sure of a continuous supply. In Germany manufacture of starch from potatoes is an established industry. In fact, practically all the commercial starch produced in Germany, Poland, Holland, and some other European countries comes from potatoes. Methods of similarly utilizing surplus potatoes in the United States are under consideration in the department. Research on the industrial utilization of potatoes is going forward along many lines, including the manufacture of potato starch, potato dextrin, potato flour, dried stock feed, and potatoes as a source of industrial alcohol for motor fuel. The possibility of utilizing the same plants for the manufacture of both sweetpotato and potato starch is being studied. This can be done in localities where both crops are grown. Attempts to utilize potatoes and sweetpotatoes are not being restricted to starch production alone, but include the production of modified starches, dextrins, etc.

Industrial Uses for Corn

Numerous industrial uses for corn have been developed in line with research work originally launched in the Department of Agriculture. Formerly cornstarch for cooking and laundering was about the only industrial product made from corn. Private scientific investigations then showed how a sirup and a sugar could be made from cornstarch and the by-products of starch manufacture converted into valuable products. To-day, from the waste of the corn kernel after the starch is removed, the industrial chemist produces corn gluten, a highly valuable feed; from the germ of the corn he obtains corn oil, an edible oil now largely used in salads and for cooking. Large quantities of corn are now annually consumed in the corn-products industry. Progress has also been made in finding additional uses for other cereals, as well as for fruits and vegetables that might otherwise go to waste.

Processes developed by the department for the dehydration of fruits and vegetables have been helpful to the dehydration industry. In Idaho and Washington commercial dehydration plants use these processes, or developments thereof, for the drying of prunes and of surplus apples. Some success has attended commercial developments in New Orleans, Chicago, and Niagara Falls in the dehydration of vegetables. Sweet corn is dried commercially in Pennsyl-

vania and Ohio. Dehydration as a method of food preservation has great possibilities, but research is necessary to develop means of retaining the color, the flavor, and the vitamin content of fruits and vegetables, and also to devise effective methods of packaging, etc. The department has temporarily dropped its researches on dehydration problems, since Congress has not continued the appropriation for the work.

Utilization of farm by-products for the production of alcohol for motor fuel and for other industrial purposes has important possibilities. Surplus corn, surplus potatoes, and materials rich in starch generally are potential sources of alcohol, and methods of obtaining it have been investigated in the department. The practicability of using alcohol as a motor fuel has been demonstrated. Chemical and automotive engineers have solved the technical problems involved, and the commercial utilization of alcohol for fuel is now wholly an economic problem. Should scarcity raise the price of gasoline to a parity with the cost of producing alcohol, the latter product will probably become a motor-fuel competitor of gasoline. At present by-product molasses is largely used in the manufacture of industrial alcohol, but there are many other possible sources, especially cull and surplus fruits and cannery wastes.

Gossypol Poisoning Danger Nonexistent

Recent work in the department, which elaborates and verifies previous studies made by State experiment stations, should increase the commercial utilization of cottonseed meal. It has been shown that the supposed danger of gossypol poisoning from the use of cottonseed cake meal as feed for livestock does not exist. When properly treated and refined, cottonseed meal is a useful feed, though its protein alone is not adequate for optimum growth and nutrition. This shortcoming, however, may be corrected by the addition of other feeds. In the past, because of its presumed toxicity much cottonseed meal has been used as fertilizer. With a better understanding of the proper use of this product in feeding livestock the demand for it should greatly increase. Cottonseed, formerly almost wholly wasted, now is worked up into products having a yearly value estimated at more than $250,000,000. Rayon is manufactured from linters, the fuzz on the seed.

Experiments conducted in the department indicate possibilities in the utilization of peanut shells in floor-sweeping compounds, in dynamite, and in linoleum. Peanut shells are a possible source of alpha cellulose, the basic substance in the production of rayon. Chemists in the department have produced a beautiful alpha cellulose from peanut shells, though the product lacks certain physical properties necessary in the profitable production of artificial silk. Further research may correct this defect. Paper board comparing favorably with commercial wall board has been made experimentally from peanut shells. Peanut meal has been demonstrated to be valuable as a feed supplement, and peanut flour combined with wheat flour makes a nutritious and palatable bread.

Grease and Potash from Raw Wool

In cooperation with wool growers the department has developed improved methods of recovering and utilizing the grease and potash contained in raw wool. Heretofore a large part of the by-products of wool scouring has been disposed of as sewage at a total loss. The possibility of eliminating this loss is now indicated. Other studies have shown that crude wool grease when properly refined is useful for currying leathers and waterproofing canvas. Further study may develop new uses for it.

Many by-products of the farm and of the forest are actual and potential sources of tannin, an essential material in the manufacture of leather goods. Studies in the department have laid the foundation for the development of new supplies of tannin through the utilization of miscellaneous plant products and wastes. This work holds great possibilities in view of the fact that the present source of more than one-half our domestic supply of tannin is the American chestnut tree, which seems doomed to extermination by the chestnut blight.

FARM FIRES

The farmer loses a material part of his annual income by fire. It has been estimated that fires on farms annually take a toll of about $100,000,000 worth of property. At the request of the National Fire Protection Association, the farm insurance organizations, and other interested agencies, the department has undertaken a study of the causes of farm fires and of means of preventing them.

Special attention is being given at this time to spontaneous heating of farm products, which causes annual losses amounting to millions of dollars. These losses take two forms—namely, actual fire and spoilage of stored products by overheating. In 1927, according to the National Board of Farm Underwriters, farm-fire losses from unknown causes on property insured by its member companies amounted to $12,151,314, and it seems probable that a substantial part of these occurred from spontaneous ignition. Corresponding figures are not available for the far larger part of the farm property which is insured in farmers' mutual fire insurance companies or for that part which remains uninsured. Other causes of farm fires are lightning, defective chimneys and flues, sparks on combustible roofs, matches and smoking, careless use and storage of gasoline and kerosene, and faulty electrical wiring.

Improperly cured or damp hay (especially the legumes), when stored in large masses, or hay which has become wet subsequent to storage, is particularly subject to spontaneous or self-generated heating. Under certain conditions, as yet undetermined, this heating will progress until spontaneous ignition occurs. The Bureau of Chemistry and Soils of this department is studying the chemical, bacteriological, and engineering aspects of this problem. Laboratory research and also large-scale field experiments are being conducted on the department's farm at Beltsville, Md. Hay in storage is being studied under conditions believed to be ideal for spontaneous heating, and also duplicating as nearly as possible the conditions on

farms. The results obtained should yield fundamental data, together with information on practical measures to reduce farm-fire losses.

FERTILIZER PRACTICE

The commercial-fertilizer industry has been going through a gradual but distinct evolution during the past 10 or 15 years. There has been a constantly increasing use of inorganic fertilizer materials, a tendency toward the elimination of low-grade fertilizers, and increased use of synthetic fertilizer salts. These changes are fundamental. Greater use of inorganic materials means that the fertilizer industry is becoming a chemical industry. Formerly it utilized to a large extent the by-product materials of the packing house and mill. Remarkable progress has been made recently in the development of synthetic fertilizer materials, notably in the fixation of atmospheric nitrogen.

These new nitrogen materials are characterized by high plant-food concentration. New compounds of phosphoric acid have been developed which contain high percentages of this food constituent. Potash salts of high potash content are available, and there has been rapid development of concentrated fertilizers containing 30 or more per cent of available plant food. The department, in cooperation with a number of the State agricultural experiment stations, is conducting a wide range of experimental work to compare concentrated fertilizers with ordinary-strength fertilizers on prominent soil types. If the farmer can satisfactorily utilize this concentrated material, considerable savings in freight, handling, hauling, and other items will result.

In sections where the soil has good water-holding capacity and rainfall is adequate concentrated fertilizers show up well in comparison with those of ordinary strength. On light sandy soils in the coastal plain section, where rainfall may be scanty at and following planting, more experimental work is required as to the placement and distribution of concentrated fertilizers and as to the degree of thoroughness with which they should be incorporated with the soil. It will not be practicable to make definite recommendations until this work has been done.

It is necessary also to develop fertilizer-distributing machines with suitable attachments to insure the proper application and incorporation of the fertilizer with the soil. In some sections, where large quantities of fertilizer are applied to the acre, the use of concentrated fertilizer has passed the experimental state, and farmers are discovering its advantages. On crops which ordinarily receive only a few hundred pounds of fertilizer to the acre, ordinary-strength fertilizer will probably continue to be used, as it is more easily applied uniformly.

Chief Plant-Food Elements

The chief plant-food elements around which experimental field and greenhouse work has heretofore been largely centered are nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, carbon, hydrogen, oxygen, and iron. In fact, the fertilizer industry has

been developed on the principle that nitrogen, phosphorus, and potassium are the key plant-food elements. As a result, the industry has largely confined itself to the production of fertilizers containing mixtures of nitrogen, phosphoric acid, and potash carriers. Inquiries have recently arisen concerning some of the less common soil elements. These include manganese, magnesium, boron, iodine, fluorine, copper, iron, chromium, vanadium, titanium, etc. Studies are under way to determine whether deficiencies of one or several of these rarer elements may interfere with plant growth and development. The subject is of considerable importance. Preliminary experiments indicate that a small application of certain of the so-called minor elements of plant food is an advantage. The effect of manganese on a highly calcareous soil in Florida, where tomatoes are commercially grown, is a striking example. On this soil the difference between success and failure may be determined by the use of manganese compounds. As light an application as 50 pounds of manganese sulphate to the acre prevented chlorosis, stimulated vegetative growth, and insured commercial growers a successful crop.

Deficiencies of the less common soil elements may also prove detrimental on light sandy soils, such as are found in the Atlantic and Gulf coastal plains regions. This is particularly true of soils that are subject to constant leaching. There is some evidence that the continued use of relatively pure synthetic salts in fertilizers on certain soils may prove detrimental, owing to the absence of impurities which, in ordinary fertilizers, supply some of the less common elements. The questions involved deserve thorough investigation under field conditions.

FOOD AND DRUGS ACT

The enforcement of six laws designed to keep our markets free from adulterated and misbranded foods, drugs, insecticides, and naval stores has done much to advance the interests of farmers and ranchers. These laws—the food and drugs act, the tea act, the insecticide act, the naval stores act, the import milk act, and the caustic poison act—are enforced by the Food, Drug, and Insecticide Administration, a regulatory unit of the department established for that purpose on July 1, 1927, by act of Congress.

The economic advantage to country and town buyers alike of being protected against traffic in foods and medicines that are not what their labels represent them to be has been pointed out in previous reports. The application of the food and drugs act to the sale of stock foods also guards the farmer against having to pay high-protein feed prices for feed of low-protein content, and the application of the insecticide act insures truthful statements on labels for the insecticides and fungicides used throughout the country in the producers' war against insect pests and fungous diseases.

Perhaps the most outstanding accomplishments of the year under these acts, so far as the farmers' and ranchers' interests are concerned, however, have been the changes effected in the claims under which veterinary preparations and insecticides for use on livestock and poultry are offered for sale. Many of these preparations, of course, have always been put out by honest and painstaking manu-

facturers, who saw to it that no promises that could not be fulfilled appeared on the labels or in the circulars accompanying the packages of their products. But unfortunately many others were sold under claims for cures that could not possibly be accomplished by any of the ingredients used. The best example of what has been done against such preparations is the action taken some time ago against an alleged cure for contagious abortion, found on analysis to consist of nothing more than brown sugar and wheat bran. Nine and one-half pounds of this "cure," which cost less than 40 cents to produce, was sold for $5. Seizure, under the food and drugs act, of shipments of this product throughout the country resulted in its removal from the channels of trade. The manufacturers claimed that their sales amounted to about $15,000 each month before the Government took a hand in the matter. Putting an end to this fraud alone saved dairymen at least $180,000 a year.

Present-day reliable veterinary medical opinion holds that no known drug or mixture of drugs can be considered efficacious in the treatment of such diseases as contagious abortion of cattle, hog cholera, hog flu, fowl cholera, diarrhea of chicks, coccidiosis, roup, gapes, chicken pox, blackhead of turkeys, distemper of dogs, black tongue and running fits of dogs, influenza, distemper, and heaves of horses. In spite of this well-established fact, preparations prescribed for use in such affections are constantly being put out. As a result of an intensive campaign under the food and drugs act, the greater part of these alleged remedies, which a few years ago flooded the market, have either been entirely withdrawn or have had their labels and circulars so changed as to prevent their being bought under misapprehension of what they can really do.

Action in Regard to "Worm Expellers"

The great array of "worm expellers," "mineral mixtures," "stock powders," "conditioners," and "tonics," offered to the agricultural public under false and fraudulent claims, have recently come under the ban of the law. For instance, drastic action was taken against a preparation labeled "Worm Eradicator," when chemical analysis showed that it contained approximately 95 per cent of water and 5 per cent of material utterly worthless against worms of any type in poultry or any other animal.

The sale of preparations to be administered internally to poultry afflicted with lice and mites constitutes another fraud against which the department has proceeded, in this case under the insecticide act. Court action was taken, and a verdict for the Government rendered, against a preparation for which the manufacturers claimed that one-half teaspoonful in each gallon of drinking water provided for poultry would rid the fowls of all lice and mites. Chemical analysis showed that this product consisted of about 8 per cent of lime and sulphur and 92 per cent of water. Entomological examinations showed that it would kill neither lice nor mites.

American farmers and ranchers annually spend millions of dollars on veterinary preparations of one kind or another. Unless such preparations will do what their manufacturers say they will, this expenditure is a great financial loss. Even more serious than the loss of good money, however, is the false sense of security thus

attained, leading, as it often does, to the spread of a disease throughout an entire community before proper scientific methods of control are begun. The need for legal action to prevent fraud of this sort will doubtless continue indefinitely; rapid strides, however, in ridding our markets of falsely labeled veterinary preparations have recently been made through cooperation with the industry. Manufacturers are showing an increasing desire to comply with the spirit as well as the letter of the law by voluntarily removing misbranded preparations from the channels of trade and revising their labels and circulars to eliminate all claims that are not fully warranted by the composition of their products.

PLANT-INDUSTRY DEVELOPMENTS

Postwar agricultural developments emphasize the necessity of systematic effort to regulate farm production in accordance with market needs. This calls for a determination in advance of the acreage required. Any such determination can of course be only approximate, since production depends not on acreage adjustments alone but also on the weather and on other unpredictable influences. Yet acreage adjustments are extremely important. The annual variation in the outturn of some leading crops is mainly dependent on annual variations in acreage. It is imperative, however, if acreage adjustments are to serve their purpose adequately, that the crops grown shall be well adapted to their climatic and soil conditions, and also reasonably immune or resistant to pests and diseases. Production can be better influenced through acreage changes when the varieties planted may, under normal conditions, be relied on for reasonably stable performance.

Overproduction, with resulting low prices, may follow underproduction due to regional crop disasters. Such disasters, though frequently the result of climatic conditions, are by no means always thus caused. They may be due largely to the ravages of insect pests or plant diseases. Research and experiment in the Bureau of Plant Industry of the department have developed many important plant varieties with disease and pest-resistant qualities. Such dependable varieties may play an important rôle in efforts to stabilize production. In fact, the reduction of seasonal hazards in this way has already contributed much to the better adjustment of supply to demand relationships. A glance at what has been accomplished will illustrate the principle involved.

Hazards in wheat production under dry-land conditions, for example, have been much reduced by the introduction of hard red winter wheats from Russia and by the development therefrom of improved pure lines or hybrids such as Kanred, Oro, Regal, and Newturk. Drought-resistant and rust-resistant varieties of durum wheat are a factor in stabilizing production in the northern part of the Great Plains. In the Pacific Northwest average acre yields of wheat have been increased about 3 bushels without appreciable additional cost, by the application of the department's discovery that early plowing of stubble for summer fallow is valuable. Rust losses in the North Central States have been much reduced by the eradication of more than 17,000,000 barberry bushes. In the eight years from 1921 to 1928, inclusive, average annual losses from rust in this

region were only about one-third of what they were during the 6-year period 1915–1920. In the dairy belt oats production per acre has been increased by the development of pure-lime varieties. Cereal smuts have been much reduced through the development of fungicides.

Control of Seed and Soil Borne Organisms

In the Corn Belt success has been achieved in the control of numerous seed and soil borne organisms that cause rots in the stalks, roots, and ears of corn plants. Soil treatments have been developed for lessening the harmful influence on the corn plant of iron and aluminum in the soil. Field practices have been developed that prevent severe injury to young flax from heat canker. States where flax culture had been abandoned have resumed the production of that crop as a result of the development by the bureau of wilt-resistant varieties. Research on the wheat nematode resulted in the control of this pest, and research on flag smut of wheat ended in the practical extermination of the disease.

Cane-sugar production in Louisiana, which was threatened with extinction by mosaic disease, has been rehabilitated by work done in the department. Unofficial estimates of Louisiana's 1929 sugarcane area place it at 225,000 acres. This compares favorably with the acreages grown before the appearance of mosaic disease. This disease was discovered in 1919 in a small area in the eastern part of the State. For three years its harmful effect was little noticed. Thereafter, however, the disease spread rapidly through Louisiana and other sugarcane-growing States. In 1926 the yield from 128,000 acres in Louisiana was only 47,000 tons of sugar. It was evident that the varieties of cane then grown could no longer be relied upon for the production of sugar and sirup. Great areas of cane lands passed out of cultivation. Sugar mills remained idle, and the sugarcane industry faced collapse.

Mosaic-Resistant Cane

Following a survey, the Department of Agriculture imported varieties of sugarcane known to be tolerant of the mosaic disease. These varieties, propagated from cuttings, occupied one-fourth of the sugarcane acreage in Louisiana in 1927. In that year 71,000 short tons of sugar was produced from 73,000 acres. In 1928, 175,000 acres were planted to sugarcane in Louisiana, approximately 135,000 acres being planted to the new varieties. It is estimated that cane from 200,000 out of the 225,000 acres planted this year will be available for the production of sugar. Disease-tolerant varieties of cane have also been established in the sirup-producing areas, where they are rapidly replacing the old varieties. Thus, in a few years a threatened industry has been reestablished upon a sound agricultural and economic basis through scientific knowledge. Further improvement of sugarcane varieties is expected from experiments with new types of breeding stock obtained in an expedition to New Guinea. In this expedition the department's plant explorers visited hitherto inaccessible regions by airplane.

Soybean production has increased tremendously in the United States during the last decade, and about half of the gain is traceable to the introduction of improved varieties by the Department of Agriculture. These varieties are adapted to a range of conditions quite beyond the possibilities of the varieties previously grown. They have made the production of soybeans more certain and more profitable and soybeans have been usefully substituted for other staple crops with which they do not compete directly from the standpoint of consumption. With the corn-borer menace in corn production, soybeans may become a still more important stabilizing factor in the agriculture of the Corn Belt. Sudan grass, introduced from Africa in 1909, is now grown to an amount exceeding $15,000,000 in value annually. Alfalfa production has been much increased through the development of hardy strains. The area in alfalfa in 1928 in the States from Wyoming and Montana to the Atlantic coast exceeded 5,651,000 acres, as compared with only 3,179,000 in 1919.

Sorghums introduced by the department have done much to stabilize agriculture in the semiarid regions. In 1928 more than 10,000,000 acres [1] of sorghums were grown in the United States, chiefly in the southern Great Plains. This crop provides the wheat farmer of the semiarid regions with dependable feed, both grain and forage. In the Southern States the department encourages the improvement of pastures by disseminating information about Bermuda grass, carpet grass, Dallis grass, and Lespedeza. It has introduced Bahia grass, centipede grass, and Korean Lespedeza into this region. These grasses, when properly cared for, provide pastures in the Southern States equal in carrying capacity to the best bluegrass pastures of the Northern States. This is a contribution of great value to the livestock industry of the South, which requires improved pastures as a basis for needed expansion.

Asparagus Growing Protected

Disease-resistant strains or types of asparagus developed in the department have saved a menaced industry. Asparagus rust and the losses resulting therefrom have thus been much reduced. The strains developed in the department, besides being resistant to rust, are superior in vigor, size, and tenderness to the stocks formerly planted. Much of the risk in tomato production has been eliminated by the development of improved varieties in the department. A number of varieties highly resistant to certain diseases and superior in table quality are now commonly grown. Stem-end rot of watermelons, formerly a serious factor in transportation to market, can now be reduced to a negligible degree by simply disinfecting the cut end with Bordeaux paste. Average yields of potatoes have steadily increased in recent years as a result of the increased use of disease-free seed and high-yielding strains. In 1928 the average acre yield of potatoes in the United States was 121 bushels, as compared with 98 or 99 bushels prior to about 1920. Through better seed and better pest control, growers have acquired increased power to regulate their output.

[1] This figure includes estimates for a number of States for which detailed figures are not available.

In accordance with experimental results showing the importance of prompt cooling of fruit for satisfactory shipment, a portable car-precooling apparatus has been invented and made available for use throughout the fruit districts of the United States by securing a public-service patent. The device was designed primarily for highly perishable fruits, such as strawberries and peaches, and has been used with much success in conditioning car lots of strawberries and peaches in the South. The principle on which this apparatus works is to reverse the natural air circulation of the refrigerator car, utilizing small motor-driven blowers to pull the air into the ice bunkers through the bottom bunker opening up through the ice and out into the body of the car on top of the load. With this apparatus cars may be loaded according to standard practice and precooling accomplished without disturbing the load during or after cooling operations. When it is considered that the more rapidly a highly perishable commodity can be cooled after harvesting, the greater the possibility of the storage period being extended, it is reasonable to assume that the precooled commodity can be transported and remain in good condition a greater distance than a nonprecooled commodity.

Losses Reduced in Handling Oranges

Losses from decay or oranges in transit have been much reduced through the department's discovery that blue mold can be prevented by handling the fruit so that the skin will not be injured. Much advantage has resulted from the standardization and improvement of varieties. The Valencia variety of California is now produced in a quantity nearly equal to that of the Washington Navel. As the navel orange is shipped during the winter months and the Valencia in the spring, the two varieties furnish a comparatively uniform and constant supply from California throughout a large part of the year, to the advantage of growers, shippers, and consumers. In Florida, growers have almost unanimously adopted a list of four or five oranges that ripen in sequence during the Florida orange season. Production of Satsuma oranges has been made more profitable by a treatment whereby fruit that is green, though fully ripe, can be turned yellow. Much of the Satsuma orange crop attains prime eating maturity while the skin is still leaf green. In this condition it is unmarketable because of its color. Subjecting the fruit to a certain gas destroys the green pigment, and the desired yellow or orange color becomes dominant. In this way the fruit can be marketed when in its best condition for eating and when there is relatively little competition from other varieties.

During the past year a first-hand study of the date varieties of the Mesopotamian region has been made by specialists of the Bureau of Plant Industry, with special reference to locating, if possible, varieties suited to some of our southwestern valleys where the occasional occurrence of untimely rains during the ripening season renders the north African varieties unsuited to commercial culture. Offshoots of a number of interesting and promising varieties were secured, which will be tested under conditions existing in this country, particularly in the lower Rio Grande Valley in Texas, where there is much interest in the possibility of establishing the commercial production of this crop.

Boron Injury to Plants

In view of the recent discovery that certain plants, such as oranges, lemons, and walnuts, are especially sensitive to small quantities of salts of boron in the soil moisture, material progress has been made in the investigation of this problem. It has been found that with the more sensitive plants boron injury may occur from the use of irrigation water containing boron in excess of 5 parts in 10,000,000. From the surveys conducted during the past year it has been found that certain irrigation waters in California and Nevada carry injurious quantities of boron, but it has also been found that in general the boron occurring in surface water supplies may be traced to one or more comparatively limited sources, so that by diverting these wells or streams from the main water supplies it appears possible to reduce the boron concentration below dangerous limits. Since some crop plants are much more tolerant of borax than others, it appears probable that the waters with relatively high boron content may be utilized for irrigation of those crops that are usually benefited or at least not injured by boron content above the safe limit for citrus fruits or for walnuts. The California Agricultural Experiment Station is cooperating with the Bureau of Plant Industry in these investigations.

Scab Disease of Wheat and Barley

The scab disease of wheat and barley, which occurs more or less commonly each year in the more humid areas of America and Europe, caused heavy losses of spring wheat and barley in some of the Corn Belt States in 1928, particularly in parts of Ohio, Illinois, Indiana, and Iowa. When fed to hogs, scabbed barley produces digestive troubles. The fact attracted wider attention than usual, owing to the exceptional extent of the scab outbreak. Extensive feeding experiments were conducted in the department with scabbed barley. Barley containing more than 10 per cent of scabbed kernels is unpalatable to hogs, and many hogs will not eat it. It was found, however, that such grain may be fed to cattle and sheep with safety. Chemical studies of a preliminary nature indicated that in scabbed barley three general types of change took place: (1) starch and dextrin hydrolysis to dextrins and glucose, respectively; (2) fat hydrolysis with marked increase in fatty acids; and (3) protein hydrolysis with increase in basic and water-soluble nitrogen. It has not yet been definitely determined which class of substances causes the trouble with swine, but the water-soluble nitrogen fractions are believed to be the cause. The area affected by the scab disease in 1928 usually produces only a small part of the barley and spring wheat grown in this country. It produced more than usual last year because barley and spring wheat were largely used to replace winter wheat that had been winterkilled.

Cause of Scab

Scab is caused by a parasitic fungus (*Gibberella saubinetii*). It attacks rye, barley, oats, corn, and some wild grasses as well as wheat. One stage of the fungus occurs on old cornstalks, from

which it may be transmitted to wheat or other small grains, when those crops are sown following corn, if the old cornstalks have not been plowed under. Removal or burial of old cornstalks reduces the infection to such an extent that the scab does not cause serious losses to the crops that follow the corn. Scab-resistant varieties are being developed by the department in cooperation with State experiment stations. Such varieties of barley as Norka, Progress, Resaca, Illinois No. 1, Oderbrucker, and Manchuria are fairly resistant. Treating well-cleaned seed with one of the standard mercury-dust disinfectants is a helpful control measure.

Control of Bacterial Spot

Gratifying progress has been made in the practical control of bacterial spot, a disease which attacks the twigs, leaves, and fruit of the peach, causing heavy losses in Illinois, Indiana, North Carolina, South Carolina, Arkansas, Tennessee, Kentucky, and the Maryland-Delaware-Virginia Peninsula. Trees in a high state of vigor tend to be resistant, and therefore fertilization, pruning, etc., are of great value in preventing losses from the disease. Work upon the problem of developing a spray which could be applied repeatedly to the peach without injury, which would be cheap, and yet control the disease, was begun in 1925. Of about 200 different sprays tested during this period, one composed of 4 pounds of zinc sulphate combined with 4 pounds of hydrated lime, in 50 gallons of water, has given definitely favorable results. Supplementary to proper fertilization, pruning, and other good orchard practices, six applications of the zinc-lime spray at intervals of two weeks beginning at petal fall have, in experimental tests, given satisfactory control. In these tests it has greatly checked the disease on leaves and fruits, has not injured any part of the trees even when used at double strength, has stimulated leaf development, and can safely be used with the insecticide, arsenate of lead. The ingredients are cheap and easily obtained.

Phony Disease of Peach Trees

After several years of intensive investigation of the mysterious phony disease of peach in Georgia with negative results, late in 1928 the communicability of the disease from the roots was established. After all the usual known methods of artificial transmission of virus diseases affecting trees had been tested and had failed, the grafting of diseased roots on healthy peach roots gave positive results. The communicability of the disease being thus established, a quarantine to prevent its spread on the roots of nursery stock from the infected region to other sections was established, and an extensive cooperative program of control of the disease by promptly eradicating all trees found infected has been started. Much research work upon the disease still remains to be done to determine the natural infection method, and in the direction of finding or developing disease-resistant stocks suitable for the peach. However, the progress already made is sufficient to encourage the expectation that this disease, which recently assumed such proportions as to threaten the

extensive peach industry of our South Atlantic States, will eventually be brought under control.

LIVESTOCK-DISEASE CONTROL

Livestock production is gradually being protected from the hazards and losses caused by disease, and made more profitable through knowledge gained by experimental work on breeding, feeding, and management. The suppression of animal diseases and parasites is accompanied by the strengthening of barriers to exclude plagues and pests that cause heavy losses in other countries. Our extensive foreign commerce involves constant danger of the occasional appearance of foreign diseases, especially at or near seacoast ports. But the department takes every reasonable precaution and is prepared to deal promptly with any outbreaks that may occur.

An outbreak of foot-and-mouth disease in January, 1929, was quickly eradicated. The country had been free from this malady for several years. It principally affects cattle, sheep, swine, and goats, and its great danger lies in the degree to which it reduces meat and milk production, and in the extreme rapidity with which it spreads. The infection entered through garbage from a merchant vessel that had taken on a quantity of fresh meat in South America. The ship docked at San Pedro, Calif., the harbor of Los Angeles. Hogs on a Los Angeles County ranch developed the disease after being fed garbage from the vessel. Several hundred swine on the same ranch became infected within a few days.

Prompt and vigorous action was necessary. Accordingly, the United States Department of Agriculture, cooperating with State and county officials, established a protective quarantine about the hog ranch, and slaughtered and buried the entire herd, numbering 3,271 animals. Some cattle on near-by premises were slaughtered and buried also. Inspectors then undertook to trace any infection that might have spread while the disease was in the incubative stage. In a few weeks the disease developed on four other premises within a few miles of one another. All the animals on these premises were promptly slaughtered and buried even when only a few showed symptoms of the disease. By this drastic action the outbreak was restricted to the five premises mentioned. As on previous similar occasions, owners of the condemned livestock were reimbursed, at a fair appraisal, for livestock and property destroyed.

This visitation of foot-and-mouth disease caused less loss to the livestock industry and less interruption to business than any previous outbreak. It lasted only two months, setting a record in quick eradication. A noteworthy detail of the eradication proceedings was the prompt inclosure of infected or seriously exposed premises with a high fence of chicken-wire netting. This barrier restrained dogs, poultry, and other small animals, as well as unauthorized persons, from entering. It aided the guards at gateways in maintaining a rigid quarantine. The success of the eradication shows the importance of maintaining a well-trained force of veterinarians for such emergencies. Occasional outbreaks need not cause undue alarm, but should be the signal for energetic, cooperative action. Regulations for excluding foreign maladies are our first line of defense, but can not be relied on exclusively.

The infectious poultry malady, European fowl pest, which appeared in the United States in 1924 and was eradicated in 1925, made a second appearance in June, 1929. The outbreak involved eight premises in Morris County, N. J. It was so promptly diagnosed and suppressed that the losses were without economic significance. Eradication was effected essentially through the destruction of affected fowls, and the cleaning and disinfecting of premises. No other foreign livestock diseases gained admittance to the United States during the last fiscal year.

Eradication of Bovine Tuberculosis

Progress is being made in combating bovine tuberculosis, tick fever, hog cholera, sheep and cattle scabies, and various other domestic maladies. In the campaign against bovine tuberculosis more cattle were tested in 1928-29 than in any previous fiscal year. Nearly a million cattle a month were tested, the total in round figures being 11,665,000. The degree of infection found was 1.8 per cent, as compared with 3.9 per cent about eight years ago. These results and other data indicate that tuberculosis among cattle has been reduced more than 50 per cent since systematic eradication began.

Two States, North Carolina and Maine, were designated during the year as modified accredited areas; that is, areas in which tuberculosis infection among cattle has been reduced to less than one-half of 1 per cent. This was a significant demonstration that bovine tuberculosis can be eradicated from large areas. The work began with individual herds and was extended first to a county-wide and eventually to a state-wide basis of testing. Other States are rapidly approaching the goal attained by North Carolina and Maine.

Some 740 counties in the United States have attained the designation of modified accredited areas. The work is progressing in about 460 other counties. Thus area work has been completed or is under way in 1,200 counties, or considerably more than one-third of the counties in the United States.

State Action in Eradication Work

In nearly all States the legislatures were in session during the fiscal year 1929 and, with few exceptions, provided legal authority and appropriations to facilitate bovine-tuberculosis eradication. Some States modified their laws to make possible the extension of county-wide testing, so that all counties might have the opportunity to become modified accredited areas within the next few years. Moreover, State legislatures showed a tendency to increase the amount of compensation paid as indemnity to owners of cattle condemned as tuberculous. Federal indemnity was increased to permit a maximum payment of $75 for purebred cattle instead of $50 as before, and a maximum of $35 for grade cattle instead of $25.

Prevention of the spread of bovine tuberculosis by the summary destruction of diseased animals was held to be constitutional by the Supreme Court of Ohio in its recent decision in Kroplin *v.* Truax, 165 N. E. 498. Compensation to the owner is not a prerequisite to

the exercise of such authority, since the destruction of the animals is merely the abatement of a nuisance. If compensation is given, it is a mere gratuity. The decision in this case is in accord with prior decisions of the courts of other States. The principle of law involved now seems to be well settled.

It is necessary for a county recognized as a modified accredited area to qualify for reaccreditation after a period of three years. Under this provision 104 counties whose modified accredited status recently expired made further tests of their cattle. The results again showed that the degree of infection did not exceed one-half of 1 per cent, and indicated that areas in which tuberculosis has been reduced to a negligible quantity can be kept so by proper precautions. Ample funds for tuberculin-testing work during the coming year promise further progress.

Infectious Abortion

With the gradual suppression of tuberculosis, infectious abortion appears as the greatest plague now affecting our cattle industry. This disease takes an annual toll, from both beef and dairy herds, estimated at fully $50,000,000. The disease also affects hogs. Hence the total damage is considerably more than the figure mentioned. No large part of the country escapes its ravages entirely, though the older dairy sections suffer most.

Stock breeders and dairymen manifest growing interest in the control of this baffling malady. Control methods based on present knowledge, though successful in many cases, have not proved practicable in all, owing to the labor, equipment, and expense involved. There is urgent need for a simple and effective means for combating the disease. Especially desirable is an effective and inexpensive system of artificial immunization. Encouraging experiments have been made, and further studies are in progress. Recent observations indicate that the eye may be an important channel of infection.

Increased appropriations for the study of infectious abortion were made available by Congress for the year ending June 30, 1930. The department will continue its independent investigations, and undertake in addition an expanded research program in cooperation with several State experiment stations. Both technical experiments and field trials will be made.

PACKERS AND STOCKYARDS ACT

As is the case with most new regulatory acts of broad scope, the Secretary's authority has been challenged in connection with the enforcement of the packers and stockyards act. This measure, passed in 1921, vests in him certain authority over packers, stockyards, and market agencies and dealers operating in public livestock markets. It is the policy of the department to obtain a ruling by the courts in all cases in which its orders under the act are questioned. One case was decided by the United States Supreme Court during the year; another is now pending in that court.

The case decided was that of the United States *v.* American Livestock Commission Co. et al.—the so-called Oklahoma boycott case. The decision, handed down May 20, 1929, sustained an order of the

Secretary against certain market agencies and livestock dealers operating at the Oklahoma National Stockyards. In this order, issued March 31, 1926, the Secretary directed the agencies and dealers concerned to cease using unfair or discriminatory practices in the purchase and sale of livestock. Specifically, the order prohibited the respondents from agreeing among themselves to refrain from dealing with the association. The market agencies and dealers urged that there was nothing to prevent their dealing or refusing to deal with whom they chose. With respect to this claim the Supreme Court said: "But we think it does not need argument to show that a boycott of a dealer in a stockyard may be an unfair practice under the act as it is found to have been in this case."

In the pending case—Tagg Bros. and Moorhead et al. *v.* The Secretary of Agriculture, commonly known as the Omaha rate case—the Secretary prescribed rates which in his judgment would be reasonable for the handling of livestock on a commission basis by certain market agencies on the Omaha market. The district court of three judges for the district of Nebraska upheld the right of the Secretary of Agriculture to prescribe reasonable rates for this service, and sustained the reasonableness of the schedule of rates which he had prescribed.

Its decision said:

> For many years the agencies have operated under a schedule of rates fixed by their Omaha Exchange and undoubtedly the fact that rates are so fixed by an organization of which the commission men and traders are members and their customers, the livestock owners and shippers, are not, inclines public authority, to take a hand in the matter. * * * If the owners of the 58 firms or corporations comprising the respondents can, through a committee or whatever other machinery they see fit to adopt, arrive at rates to be charged the shippers, a disinterested governmental agency can fairly arrive at such rates. * * * There does seem to be an incongruity between the fact that commission men operate under uniform, fixed rates and yet make the claim that the sovereign power can not require that the rates be reasonable.

The respondents appealed, and a date has been set for argument before the United States Supreme Court.

ANIMAL-HUSBANDRY STUDIES

Animal-husbandry investigations carried on in the department now deal more largely than formerly with the business side of livestock production. Research projects no longer seek merely to determine which of two systems of producing farm animals is the better. They must tell the farmer and the stockman approximately how well each of the systems will pay. It has long been generally known, for example, that grass is the stockman's cheapest feed. Low feed costs are important. Experiments conducted under farm conditions have shown, however, that a ration costing the least per unit of gain on cattle, hogs, or sheep may not be the most profitable. Much depends on the quality of the finished product, on changing conditions in market demand, and on other factors. Results of a research project carried out in cooperation with the West Virginia Agricultural Experiment Station illustrate the point. Grass-fed steers that received a supplement of corn and cottonseed meal gained 39 per cent more and were 22 per cent more profitable than steers of the same age, weight, and quality fattened on grass alone.

The cattle that received supplemental feed had a slightly higher dressing percentage than those receiving grass only. As feeder cattle, as slaughter cattle, and as dressed carcasses, the cattle which received grain and a protein supplement graded consistently higher than the cattle fattened on grass alone. Studies of the meat produced in this experiment gave significant results. A mechanical test of the breaking strength of roasted rib muscle, and a report on the tenderness of the meat by judges of palatability, indicated that the animals given a supplementary ration produced the better meat. Besides demonstrating that the cheapest feed may not be the best, the tests showed what the better method is.

Investigations conducted in cooperation with the Purdue Agricultural Experiment Station yielded data pointing to a similar conclusion in the case of sheep. During the summer of 1928 the net return per lamb, above the cost of feed for both ewes and lambs, was $6.66 more for a flock of sheep kept on pasture than for a flock fed grain and alfalfa hay in dry lot. However, a third flock was managed by keeping the ewes and the lambs on pasture and feeding the lambs grain in a creep. These lambs netted $1.11 more per lamb than the lambs that had pasture only. These and other results from the experiments show not only the value of pasture and its profitableness as a feed for lambs, but also that a grain supplement may increase the net returns, if the grain is not too high in price.

Growth of Wool and Mohair

Another interesting investigation dealt with the growth of wool and mohair. It showed that these fibers grow at varying rates during different seasons, the growth being least in the winter and greatest during the summer and fall. As the wool fibers grow longer they increase in diameter, a fact of importance both in production and in manufacturing. Studies are in progress to ascertain the influence of nutrition and management on the growth of wool and mohair.

Diet deficiencies in pigs and the relation of such deficiencies to the development of the teeth and the skeleton are being investigated. This work is conducted in cooperation with Johns Hopkins University and the American Dental Association. It has revealed that profound changes occur in the teeth and in general development when lime or phosphorus is lacking in diets otherwise adequate. This study gives promise of supplying more definite knowledge about animal nutrition, and also valuable information relating to human beings. Rachitis or "rickets" is a common disease of children evidenced particularly by weakness of the bones. Rachitis in swine is similar and probably identical. The feeding of swine rations deficient in lime salts, though otherwise complete, resulted in marked symptoms of this disease. Feeding rations deficient in phosphorus produces similar effects, though to a less degree.

Poultry Problems

Poultry problems are receiving increased attention. Particularly valuable results have come from experiments made to delay the molting time of laying hens by feeding them sulphur compounds. Sulphur is an important constituent of hens' feathers. It was believed

that giving proper quantities of a suitable sulphur compound might either delay the molt or cause it to have less effect on egg production at the season when eggs are high in price. It was discovered that a mixture of certain inorganic sulphur compounds increases the annual egg production of both pullets and laying hens. White leghorns given the sulphur mixture produced from 12 to 21 per cent more eggs in a year than other white leghorns not given the mixture.

Means of reducing losses caused by poultry maladies are under investigation. It has been demonstrated that pullorum disease, widely known among poultry owners as bacillary white diarrhea, may spread from chick to chick in the same incubator.

Studies of poultry parasites have furnished new knowledge concerning tapeworms and certain roundworms. Several species of snails, beetles, and grasshoppers have been found to serve as intermediate hosts for various internal poultry parasites. This knowledge emphasizes the importance of the prompt disposal or droppings. In short, the poultry industry is receiving the benefit of technical studies comparable to those heretofore made regarding the larger animals.

DAIRY RESEARCH

Recent investigations in the Bureau of Dairy Industry have developed new methods of controlling bacterial fermentations in the ripening of cheese. The use of these methods makes possible a great improvement in quality of cheese. Although about 20,000,000 pounds of Swiss cheese are made annually in the United States, it is necessary to import more than 15,000,000 pounds. The imported cheese is of the better grades and commands a higher price than the domestic product, much of which is defective in eye formation and flavor. Even factories that use the pure cultures of bacteria developed by this department turn out from 5 to 15 per cent of cheese that is defective because of abnormal gassy fermentations, or has a woody rather than a rubbery texture. The defective texture is associated with the use of bacterial cultures which induce a rapid formation of acid in the warm curd while the cheese is on the press. In order to suppress abnormal gas formation it is necessary to have an acid-forming culture which will check the growth of the undesirable bacteria. A new culture which is free from these two difficulties has been found. It survives the high temperatures of the cheese kettle and is actively growing when curd is put on the press. It begins acid formation before the gas formers are able to multiply. In a large number of laboratory and factory experiments this culture has invariably suppressed abnormal fermentations without impairing the texture of the cheese.

Under present conditions skim milk is a waste product in the manufacture of butter, and much of it also goes to waste in the production of market milk during seasons of surplus. One means of lessening this waste is the use of a process developed by the department for concentrating sour skim milk. Concentrated sour skim milk will keep without deterioration for several months and does not require special care. It is sold mainly as a poultry and hog feed, and many creameries and milk plants have found it profitable to make

the product by the department's process. In the last year the department has assisted a number of plants in establishing the process and has furnished many more with cultures and detailed directions. In making concentrated sour skim milk 27 plants utilized 76,000,000 pounds of skim milk in 1928, an average of nearly 3,000,000 pounds per plant. It is made also in some plants for which records are not available. Probably 100,000,000 pounds of skim milk were used in 1928 in making concentrated sour skim milk.

Cities Aided in Improving Milk Supply

During the year the Bureau of Dairy Industry aided many cities in improving their milk supplies. It advised them regarding legislation, the unifying of inspection systems, and the proper training of dairy inspectors. City and State milk ordinances were studied and tabulated, and information about dairy inspection was sent monthly to all dairy inspectors in towns and cities. Simple and efficient methods for producing and handling milk have been worked out by the bureau. A general policy of education among dairy farmers is necessary to get these methods widely adopted. Accordingly, the bureau has made comprehensive plans for community and state-wide educational programs to be carried on through the extension agencies of the State agricultural colleges.

Dairy herd improvement associations, in which the department is keenly interested, increased in numbers from 947 to 1,090 during 1928. This was a gain of 143 associations, or approximately 15 per cent. More than 465,000 dairy cows are on test in these associations for the economical production of milk and butterfat. Their average production in 1928 was 7,464 pounds of milk and 295 pounds of butterfat, or more than 60 per cent above the average production of all the dairy cows in the country. The records proved once more that high-producing cows return a high average income over the cost of their feed. Cows producing 500 pounds of butterfat per year ate more than twice as much feed per cow as did those producing 100 pounds, but returned more than fourteen times as much net income.

HOME ECONOMICS

The department through its Bureau of Home Economics during the last year continued and broadened its studies of practical, everyday home problems important to health and satisfactory living. Nutrition principles were expressed in daily menus, and recipes for the preparation of foods were tested. The food habits of children were studied and a bulletin prepared giving nutrition facts, menus, and recipes. In this work the department cooperated with the Washington Child Research Center, with mothers, and with children's institutions. Designs for children's clothing were published in department leaflets and popular articles. Cooperative relationships were maintained with manufacturers of patterns and ready-to-wear garments, so that mothers might purchase patterns or garments based on the designs.

The quality of family living depends almost as much on how the income is spent as on the amount of the income. Accordingly,

studies were made to help the housewife in planning and recording family expenditures. A bulletin was prepared describing various methods, and a supplementary, loose-leaf account book was issued to simplify the keeping of household records. A bulletin in preparation discusses family expenditures and gives typical budgets at different income levels. Two preliminary reports were made on how time is spent in the home. These were based on the records of 1,000 rural home makers. They will be followed by popular publications on the preparation of time schedules and the planning of household tasks. Some information on the equipment used in the home laundry and in the preparation of food was assembled, but much more is needed as a basis for advice on the wise choice of such equipment. Studies on home refrigeration compared the cost of operation and management of ice and mechanical refrigerators. Bacteriological studies showed the most desirable temperatures for the household refrigerator.

The relative utility and economy of agricultural products used in the home was studied. This work included palatability tests to determine the influence of methods of production and other factors on the palatability of foods. Tests of the palatability of meat were made to help producers determine how the most palatable meat can be produced most economically. Facts were thus established which should enable them eventually to produce the kind of meat that is most acceptable to consumers.

Rice Varieties Tested

In the handling of rice geographical preferences affect marketing. The department sought to determine whether methods of cooking might be so adapted to different varieties as to make them yield a finished product of comparable texture. Eight common varieties of rice were cooked under varying conditions. It was demonstrated that different varieties of rice cook differently, some more completely and in less time than others. This indicated the desirability of avoiding a mixture of varieties in grading.

Considerable information on the composition and the mineral and vitamin content of food products, and the relation of these factors to good nutrition was obtained. Studies of food composition were supplemented by special chemical analyses.

A special study was made of two agricultural by-products, rice polish and wheat germ, which are valuable sources of certain food nutrients. It was shown that these discarded germ portions are very high in vitamin B, especially in the antineuritic factor, so important in the diet of children. These parts of the grain are generally discarded or used as feed for livestock, largely because they tend to become rancid. By slightly heating germ portions and placing them in sealed containers, however, this rancidity can be prevented. Accordingly, recipes were worked out showing how the by-products in question may be used as food. This is particularly desirable where diet is likely to be restricted in either minerals or vitamin B. This process also affords a method of utilizing a valuable part of the grain without interfering with the usual method of milling white flour or polishing rice.

Utilizing Different Grades of Products

Efforts to develop uses for all the grades of different crops, so that the entire output may find a profitable market, produced significant results. The department suggested a number of uses for osnaburg, a fabric made from low-grade cotton, and the sale of this material was stimulated so that its increased manufacture absorbed more low-grade cotton. A study to determine the influence of the quality of cotton on the durability of fabrics was begun. This and similar studies should assist manufacturers to select the grade of cotton best suited to their requirements.

Study of food-handling costs resulted in recommendations for improvement. Education in the choice of foods, an important phase of home economics, necessitates keeping in touch with the home on the one hand and the food supply on the other. It is important to consider the food supply not only as a source of economic return to the producer but also as a source of adequate human nutrition. Also it must be regarded from the standpoint of the supply as a whole, rather than from the standpoint of a single group of commodities. The need for education in the choice of foods has been increased by unethical advertising used to promote the sale of special foods.

Food Expenditures Analyzed

In studies of the farmers' standard of living, recorded food expenditures were analyzed and material prepared for publication. A beginning was made in the study of food used by business and professional groups. Information is required also regarding the food habits of families in the wage-earning and clerical groups. Information about consumer demand under changing economic conditions should make it possible to estimate market requirements more closely, and thus to improve supply and demand relationships.

FUNDAMENTAL RESEARCH IN THE DEPARTMENT

As this is an anuual report rather than a history of the department, it must be largely confined to the work of the last 12 months. But this rule can not be uniformly applied. It must be set aside entirely in reviewing research, for scientific inquiry can not be evaluated annually. It is essentially a long-time activity, which can be truly appraised only on a long-time basis. Much research started in the department and in the State experiment stations long ago is only now beginning to bear fruit. Years may pass before certain current studies yield practical results. Only by noting the outcome of research work over a long period can we form a just idea of its value. I shall therefore not restrict myself to the developments of a single year in dealing with the subject of research, but shall glance over the record of several decades.

Though some familiar facts may appear in the retrospect, the story as a whole will emphasize the latest application of the department's scientific discoveries. This phase of the matter changes constantly and increases steadily in economic importance. Scientists are accustomed to distinguish between fundamental research and studies having simply an immediate practical object. This distinction is

valid enough, but it sometimes inclines the layman to think that fundamental research is not practical. In reality it is practical in the highest and most permanent sense. It may therefore be worth while to chronicle some of the practical results of fundamental research done in the department. Time and again facts or principles thought at first to have only a scientific interest have turned out to be of revolutionary importance.

Fundamental research done in the Bureau of Animal Industry from 1888 to 1893 demonstrated that a microorganism found in the blood of cattle affected with Texas fever is the actual cause of the disease and that the cattle tick is the means whereby the disease is transmitted. This was the first demonstration that a microbial disease could be transmitted exclusively through the agency of an intermediate host or carrier. The discovery ranks among the great achievements of medical science, for it led to the knowledge that such diseases as yellow fever, malaria, typhus fever, African sleeping sickness, Rocky Mountain fever, magana, and others are carried through an intermediate host. The control of yellow fever in the Panama Canal Zone was thus made possible.

Achievements in Livestock-Disease Control

Studies begun in the same bureau in December, 1885, showed that immunity to a disease could be produced by the injection of killed cultures of bacteria. This result of fundamental research was later applied in vaccination against typhoid fever and other bacterial diseases. A technic was developed for the diagnosis of dourine in horses by means of a complement fixation reaction. This brought into use a reliable method for detecting animals affected with this and certain other insidious diseases. The test has had extensive application in this country, with gratifying results in the control and eradication of dourine of horses. It has served in detecting animals offered for import that harbored diseases not existing in this country. Later studies showed that botulinus toxin produced symptoms in horses identical with those of forage poisoning. This discovery opened a new field in the study of cerebrospinal meningitis, or forage poisoning in horses, and furnished new methods of prevention and treatment. The department recently proved that anaplasmosis, a disease of cattle, exists in this country, and the knowledge led to experimental methods of control and treatment. Previously stock owners had spent much money in treating animals sick of anaplasmosis with methods used for other diseases for which anaplasmosis had been mistaken. Though the problem is not settled, the new control measures seem to be keeping it in check to a certain extent. Further research may reveal the various carriers of the disease.

Other studies developed an effective immunizing agent—hemorrhagic septicemia agressin—against hemorrhagic septicemia or shipping fever of cattle. This product, now prepared commercially, has been an extremely reliable means of reducing losses from the disease. Approximately 3,900,000 doses were prepared in 1927, and over 3,700,000 doses in 1928. The product was manufactured to a greater extent than any other biological agent except blackleg

agressin. Its proved potency and extended use undoubtedly saved livestock owners large sums.

A research result roughly measurable in dollars and cents is the department's discovery that sodium hydroxide is a much more effective disinfectant against foot-and-mouth disease than compound cresol and bichloride of mercury, substances heretofore largely used. An enormous quantity of disinfectants is used in combating outbreaks of foot-and-mouth disease. In the California outbreak of 1924, 702 premises and more than 21,000 railroad cars were disinfected. Sodium-hydroxide, besides being a better disinfectant, costs only about one-fifth as much as compound cresol solution, and about one-third as much as bichloride of mercury.

Significance of Hookworm Discovery

Exceptionally important was the department's discovery of a new species of hookworm that is widely prevalent in the Southern States. This discovery opened a public-health problem that eventually led to the establishment of the International Health Board of the Rockefeller Foundation. Subsequently the department introduced carbon tetrachloride as a remedy for hookworm disease, and it has been used in treating more than 15,000,000 cases throughout the world. More recently tetrachlorethylene was recommended as being effective and safer than carbon tetrachloride. This is now receiving extensive tests.

Research in the department interpreted the phenomena of the large intestinal roundworm of human beings and swine. The new knowledge became the basis of a system of raising swine designed to protect these animals from roundworm infestation. This system, begun on a small scale in McLean County, Ill., in 1919, was gradually extended, with surprisingly good results. Observations on many different farms in the Middle West, involving studies of the litters of several thousand sows, showed that as many pigs can be raised from two sows under this system as are ordinarily raised from three sows under the conditions obtaining on most farms. The sanitation system produces thrifty pigs, of uniform size, practically without runts, whereas the ordinary system of raising swine produces many undersized pigs. This swine-sanitation system saves the farmers in the Corn Belt probably $1,000,000 a year. It is being tested in the South, and has been adopted on many farms there.

Some diseases, among them bovine tuberculosis and infectious abortion, require prolonged study before their fundamental facts can be discovered. Certain basic facts regarding these two diseases have nevertheless been established by the department. It has been determined that many tuberculous cattle, even when outwardly in good health and condition, eliminate living tubercle bacilli in their feces through having swallowed infected material coughed up from their lungs. This showed how hogs become infected, and indicated necessary precautions. As this discovery revealed an important channel through which the casual agent of the disease is disseminated, its economic value is undoubtedly great.

Investigations of the cause of hog cholera were begun in the department as early as 1878. They were continued almost unin-

terruptedly, but without tangible practical results until 1903, when the fundamental discovery was made that hog cholera is caused by a filterable virus. Since then progress in the control of the disease has been rapid. A preventive serum has been developed which enables farmers to engage in hog raising with security against loss from hog cholera. Further research is required to determine the nature of the hog-cholera virus. It can not be cultivated outside the hog, and it can not be seen by the highest powers of the microscope. It passes through filters. If its nature were known, science could probably combat it more effectively.

Discoveries Regarding Mosaic Diseases

Knowledge of the so-called mosaic diseases of tobacco, tomato, cucumbers, potatoes, sugar beets, corn, wheat, sugarcane, and many other cultivated crops, including fruits, is the result largely of research on the part of department and experiment station workers. The mosaic diseases are caused by filterable viruses introduced by plant lice and leaf hoppers. Threatened industries have been reestablished by the breeding of resistant varieties of the affected plants. In this way the potato industry has been protected and the sugar industry of Porto Rico and Louisiana reestablished. It was first demonstrated by this department that resistance to disease in plants is a genetic character, and that resistant qualities can be bred into or out of plants. Wilt-resistant cottons and melons were the practical outcome. These varieties made it possible to grow cotton and melons in infected soils, and saved the money crops of large regions. The principle has been applied to many other crops and diseases.

Another discovery in the department made it possible to secure crosses of species whose blooming periods are so far apart that pollen can not be preserved long enough to secure crosses. This revealed that the flowering and the vegetative growth of plants are controlled by alternations of light and darkness, and that the time of flowering can be controlled by changing the length of the periods of exposure. Thus plants with flowering periods far apart can be brought into flower simultaneously. This is of value in hybridization and in other connections.

In 1916 the department became interested in the production of citric acid by the action of certain molds working on sugar solution. A laboratory process was developed which eventually made the United States independent of foreign domination in this important product. Italy in 1928 placed a tax on the export of citrate of lime to encourage home production of citric acid. In the same year the citrus crop in the Pacific States was so good that few culls were available for the domestic production of natural citric acid. An American manufacturer, using the process discovered in the department, met the domestic demand for citric acid, without an appreciable increase in the domestic price. Meantime England and other foreign countries had to pay export taxes to meet their demands for citric acid. Citric acid sold in England for as much as 65 cents a pound, while the price here remained at 46 cents. The estimated saving to this country was $700,000. About $3,000,000 worth of citric acid is produced annually by this method.

Calcium gluconate is coming to the fore in the medical administration of calcium. It has advantages not possessed by other salts of calcium, in that it can be injected into the skin or the muscles without causing necrosis of the tissues. Moreover it is the only tasteless salt of calcium. Calcium gluconate also shows promise for the administration of calcium to poultry and cattle. If this use develops, an enormous demand will arise for the product. A new chemical process for the production of gluconic acid and calcium gluconate has been developed in Switzerland, but this process is fully protected by patents in this country and constitutes a monopoly. However, a process has recently been developed in the department for the production of gluconic acid from glucose by means of molds. This acid, formerly a chemical curiosity valued at 30 cents per gram, can now be produced by our methods for little more than that per pound.

Results from Soil-Fertility Studies

Study of the nutritional requirements of the sugar beet led to the general use of superphosphate and other commercial plant foods on the sugar-beet lands of the West. The result is a large increase in yields per acre, and also a significant increase in the sugar content of the beets. Application of this research achievement brought increased prosperity to the growers and larger profits to the sugar-beet factories.

Until about 20 years ago it was believed that there was not much difference between the various proteins with respect to their nutritive value. To-day we know that of the 18 or 19 compounds called amino acids, of which proteins are composed, some are absolutely essential for growth and nutrition. Many proteins in some of our most important foods and feedstuffs have been found to be lacking or deficient in one or more essential amino acids. Conspicious among these are the chief proteins in corn, wheat, several other cereals, and in some beans and in lentils. This new knowledge, which has revolutionized our ideas regarding the nutritive value of foods, was gained through fundamental research started in the Connecticut Agricultural Experiment Station, and supplemented by studies conducted in this department. The composition of many proteins in different foods and feedstuffs has been determined, and the percentages of the different amino acids estimated. More than 100 publications give the results, which are widely used by workers in dietetics and in animal husbandry. It is now possible to mix feedstuffs so that the amino-acid deficiency of one protein will be supplemented by adding to the ration another feedstuff which is rich in that acid. The practical value is extensive.

A new method for the production of phthalic anhydride, the most important raw material used in the production of many dye substances, was developed in the department in 1918. The process involved the catalysis of naphthalene into phthalic anhydride when naphthalene was converted into a gas and mixed with air. A public-service patent was obtained, and the process made the United States independent of foreign supplies of phthalic anhydride. More than 6,000,000 pounds of phthalic anhydride were produced

commercially in 1928 at a reduction in price representing an estimated saving of $1,000,000 a year to the American public.

Utilization of Citrus By-Products

Research in the utilization of citrus by-products was undertaken to develop methods applicable particularly to conditions in California. Methods of obtaining lemon oil, orange oil, citrate of lime, and citric acid under American conditions, with machinery and mass production superceding the laborious hand methods employed in European citrus districts, were developed and demonstrated. The Citrus Growers Exchange of California applied the results in two large by-product plants. In a recent year one of these plants utilized more than 40,000 tons of cull lemons, and produced 2,000,000 pounds of citric acid, 65,000 pounds of lemon oil, and 30,000 pounds of pectin. In value these products exceeded $750,000. Another company used 10,000 tons of surplus oranges in one year recently, and produced 50,000 pounds of orange oil, valued at more than $100,000. This was done from materials which, prior to the department's discoveries, were waste products.

Results of epochal significance have been achieved in the study of nitrogen fixation. Though too technical for extended description here, some of the outstanding points in this field may be mentioned. Manufacturers of synthetic ammonia, for example, use a catalyst developed in the department. Study of high-pressure gas reactions has produced important data used by designers of machinery and by industrial chemists. Particularly valuable have been the results of investigations in the department regarding the ammonia-vapor content of nitrogen-hydrogen mixtures in contact with liquid ammonia under pressure. Data developed are used by synthetic-ammonia manufacturers in designing condensers for removing ammonia from the nitrogen-hydrogen gas mixtures.

Experiments made in the production of phosphoric acid by electric-furnace smelting of phosphate rock have had important industrial results. Other experiments in blast-furnace smelting of phosphate rock have likewise been applied industrially. Potash extraction by a sulphuric-acid method developed in the department is used commercially, as is also glaucosil, a by-product of potash extraction from greensand. The department helped to overcome the potash shortage resulting from the war by developing a method of potash extraction from silicate rock by calcination with lime or digestion with free lime under pressure. Analytical methods developed for using fluorine, borax, and phosphoric acid in fertilizers have been adopted by the Association of Official Agricultural Chemists and are in general use throughout the country. Apparatus developed in the course of this work is commercially manufactured and distributed.

Importance of Fundamental Studies

These are only a few of the benefits the Nation derives from fundamental research done in the department. A full recital would fill volumes. It is well to emphasize the material benefits that come from well-directed research, because the work requires material support. Nevertheless, a narrow view of the purposes of science

tends to defeat its object. Scientific investigations are sometimes most fruitful when directed merely toward the discovery of fundamental principles. Hence the ultimate justification in utility may be remote rather than immediate. Results will come, which can not be reckoned in advance. Results achieved as an unexpected by-product are often more important than those originally contemplated.

Heretofore the department has met a serious difficulty in its research work. Its technical men have not been authorized to shape or change the course of their investigations in accordance with changing requirements. They have been called on to justify proposed expenditures in terms of expected concrete advantages. This is always difficult and often impossible. Research, since it seeks to penetrate the unknown, is fundamentally inconsistent with any general attempt to foresee its results. Facts learned in the course of an investigation may alter its direction and open up new possibilities. Information gained in one study may profoundly influence the development of another. When research policies make no allowance for this fact, their potential utility is reduced. Fundamental research tends to be most productive and ultimately useful when it may be modified or expanded as its accumulating results may dictate.

Lump Sum for Research Desirable

It would be extremely helpful in the department's work if a lump sum, available until expended, were appropriated for basic investigations. This would permit lines of inquiry to be pursued uninterruptedly even if a radical change of their direction became advisable. Under the present system, whereby research funds are appropriated item by item, more than a year must elapse after plans are made before the funds become available. If circumstances necessitate a change of plan, another delay occurs. Many research projects progress well enough under this system. Cases often arise, however, in which the lack of elasticity in the shaping of research programs involves costly delay or even an indefinite frustration of the objects in view. Our research heretofore has been largely developed to meet emergencies and to throw up a hurried defense against diseases and pests. It has yielded important results, as the facts I have given sufficiently attest. Unquestionably, however, this method of working should be supplemented by a continuous program of inquiry into basic principles. Such a policy would accumulate forehanded knowledge which would facilitate the solution of specific problems as they arose.

STATE EXPERIMENT STATIONS

In the State agricultural experiment stations the department has strong and resourceful allies. These State institutions obtain about one-fourth of their support from the Federal Government. Besides doing much work independently, they cooperate heartily with this department in research by division of effort and also by participating in unified plans. Work thus correlated shows gratifying results. Fully 12 per cent of the research projects of the experiment stations are conducted cooperatively with the department. In this

way two great systems for agricultural investigation function in close harmony in properly balanced and well-rounded research programs.

Great expansion and development of research at the State experiment stations has resulted from the Purnell Act of 1925, which opened new fields of investigation and made it possible to attack vital questions from many angles. Fundamental research as distinguished from studies having an immediately practical objective has assumed a larger place in the work of the experiment stations. This is in accord with the experience that investigations designed to establish basic facts and principles may have more practical significance than hasty attempts to settle farm questions by short-cut methods. Essentially the distinction is not between what is practical and what is not, but what is practical in a narrow and what is practical in a wider sense. Fundamental research may not affect agricultural practice quickly in all cases. Its ultimate value, however, is sure. Certain fundamental studies launched in the experiment stations have created nation-wide interest and have led to investigations over wide regions.

An example is a series of experiments conducted at the Missouri station several years ago to determine the run-off and erosion of soils under varying conditions. This inquiry yielded results which caused it to be taken up as a national project on an extensive scale. Thus enlarged the investigation has great promise of saving fertility and conserving water supplies. Another example is a fundamental inquiry on animal metabolism initiated at the Pennsylvania experiment station. This study likewise stimulated extensive and varied investigation elsewhere. Investigators at the Wisconsin station opened up a fruitful vein by studying differences in the effects of rations derived from various plant sources. These differences were traced to variability in the elements of nutrition now called vitamins, the importance of which has profoundly influenced our viewpoint in animal and human nutrition. Research results thus pooled in the common fund of scientific knowledge pay high dividends.

Stability in Financial Support

Prominent among the factors contributing to the scientific success of the experiment stations is the stability of their financial support. The amount of Federal funds expended by the stations is determined by basic legislation. Thus assured of continuing support, the stations can plan ahead with confidence. Under the supervision of local authorities they enjoy wide freedom in choosing subjects for investigation and in deciding how the work shall be done. They can direct research to specific ends, though it may take years to reach the goal. They can change the course of their inquiries as circumstances require. This does not mean, as some critics maintain, that research projects once authorized and started are never completed but become a continuous charge. In the last year the experiment stations reported the completion of 130 projects supported by Federal funds. In other words, opportunity for research to follow its logical course is quite consistent with definiteness and a reasonably limited range. Comparative freedom of inquiry and security of

funds have been found entirely compatible with a research policy looking toward the completion of projects.

The Purnell Act, which is supervised for the Federal Government by this department, has broadened the work of the State experiment stations to include a study of economic and social problems. This is an extremely important development, because the advancement of agriculture to-day can not be accomplished by technical progress alone. It is necessary also to maintain a proper adjustment between production and market requirements, to regulate the marketing of commodities, and to establish equitable relationships for agriculture in matters of taxation, transportation, tariffs, etc. It is therefore a good augury that the experiment stations are conducting under the Purnell Act an extensive and systematic study of the economics of production. They are investigating marketing practices, taxation, land utilization, and types of farming. In the last year more than 120 station bulletins were published on work of this character. Recent developments in agriculture have emphasized the fact that farm production, no matter how efficient, does not attain its proper end until the products have been profitably distributed. The economist and the production specialist must work in close alliance. Production experiments may be safely applied only when they have been proved to be economically sound. On the other hand, radical changes in farm practice can not be recommended for economic reasons unless they are supported on the production side. This necessity for coordination between production technic and economic science is a guiding principle in the work of the experiment stations as directed under the Purnell Act, and the resulting benefit should be very substantial.

Some Economics Studies Under Purnell Act

Research in home economics carried on by the experiment stations has received a strong impetus under the Purnell Act. Investigations are progressing covering all phases of the farm woman's activities. Foods and nutrition, rural home management, textiles and clothing, rural welfare and country living, and kindred subjects bulk large among some 100 separate research projects now going forward. In several States investigations have been started to determine the bread-making qualities of different wheats. Other inquiries have to do with the quality and palatability of meat. Two general types of nutrition projects, the first involving laboratory investigations and the second consisting of field studies of dietary habits, have been launched. Much interest has been aroused by experiment station work on the food habits of children. At the Massachusetts station an investigation of the food consumption and health of rural school children disclosed serious inadequacies. It led to a broad study of the feeding and transportation of children in elementary schools and aroused wide interest among school superintendents. An analysis of the food consumption and the expenditures of rural families is being made by several experiment stations in collaboration with the Federal Bureau of Home Economics. Work done at the Cornell station on farm standards of living was followed by a considerable grant of State funds to supplement Purnell Act funds in a more

extensive investigation. Promising inquiries are under way concerning the use and economy of electrical equipment in the farm home.

Stations in Outlying Territories

In the Nation's outlying territories and in the islands of Hawaii, Porto Rico, Guam, and the Virgin Islands, the United States Department of Agriculture maintains experiment stations discharging functions similar to those fulfilled by the State stations. Valuable service was given by the experiment station in Porto Rico in restoring the island's agriculture after a devastating hurricane in September, 1928. Coffee plantations suffered great losses by the destruction of trees. It became the duty of the experiment station to advise farmers in regard to the restoration of trees not too badly broken, the preparation of seed beds, methods of transplanting, choice of shade trees, use of fertilizer, etc. Losses to citrus and pineapple growers were lessened by prompt action taken to save trees that had not been too much damaged. Many trees that had been blown over were straightened, pruned, and supported until roots developed, and were stimulated to rapid growth by the application of fertilizers. Help in solving the food problem created by the hurricane was given by the experiment station. It advised farmers as to the crops that might be planted to secure early returns.

Authority for the Territory of Hawaii to share in the Hatch and supplementary acts was given by an act of Congress approved May 16, 1928. The legislature of the Territory designated the University of Hawaii to receive the funds thereby appropriated. It is required by the act that the station shall be conducted in collaboration with the Federal experiment station in Hawaii on cooperative plans approved by the Secretary of Agriculture. Accordingly, the two stations, by agreement between the department and the university authorities, were merged for the purposes of their agricultural work. This is known as the Hawaiian Agricultural Experiment Station and is conducted jointly by this department and the University of Hawaii. The director of the Federal experiment station became director of the joint institution. Several members of the university faculty were added to the staff of the experiment station. Various research projects to be undertaken by the new organization have been approved, and the work has started under favorable auspices. This arrangement should be advantageous to the Department of Agriculture, because it offers an opportunity to develop a strong experiment station where tropical investigations can be carried on. It should benefit the Territory of Hawaii by

By an act of Congress approved February 23, 1929, benefits of local problems.

By an act of Congress approved February 23, 1929, benefits of the Hatch Act are to be extended to the Territory of Alaska. It is provided in the law "that no appropriation shall be made until estimated by the Secretary of Agriculture, the estimates to be based on his determination of the ability of the Territory of Alaska to make effective use of the funds." Plans contemplate the establishment of a new station. An experiment station has been operated

by the department since 1907 at Fairbanks, Alaska, and it is proposed that this shall be merged with the new organization. The program, however, requires Territorial appropriations for buildings and maintenance, and for some enlargement of personnel, so that research work can be carried on after the department withdraws. A bill for that purpose was introduced in the Legislature of Alaska at its recent session, but it failed to pass.

INFORMATIONAL SERVICES

Since the final test of science is practice, it is obvious that the research done by the department depends largely for its value on the efficiency with which its results are communicated to the public. Accordingly close contact is maintained between the department's scientific workers and practical men in agriculture, industry, and trade through a comprehensive information service. In this way the practical applications of scientific discoveries are made known, and scientific workers everywhere are apprised of the results achieved by their coworkers in this department. Thus duplication of effort is avoided and discoveries in one field of knowledge exert an influence on other fields promptly.

Though most of the department's work has informational aspects, a distinction may be drawn between teaching such as is carried on by the extension services and the informational work carried on through publications, the press, radio broadcasting, motion pictures, weekly and monthly periodicals, lectures and articles by department workers, correspondence with individuals, regulatory law administration, and crop and market news, and outlook reports. This work has increased measurably during the last year, though not sufficiently to keep pace with the demand. In the last half decade the department's research and regulatory work, and some other activities, have grown much more rapidly than its facilities for publishing the results. In consequence publication work is heavily in arrears, and it is unfortunately necessary to hold many important manuscripts in abeyance. A recent study indicates that 1924 was the last year in which a good balance existed between the general activities of the department and publication of the results achieved. Funds available for printing and binding have not been increased since then, though annual expenditure for research has been increased by $5,000,000, and the expenditure for department work in general, exclusive of Federal-aid roads, by $20,000,000. Indications are that the accumulation of important knowledge will outrun publication facilities to a greater degree in the current fiscal year than it did in the fiscal year ended June 30, 1929.

Information work done by the department is nevertheless very extensive. In the last fiscal year it distributed free more than 25,000,000 bulletins, circulars, periodicals, and other publications. In addition the Superintendent of Documents sold more than a million copies at prices barely covering the cost of printing. Senators and Congressmen distributed the department's publications widely, particularly the Yearbook, which has a circulation of about 400,000 copies. This volume contains the annual report of the Secretary of Agriculture to the President and numerous brief articles on recent

progress in agricultural science and practice, as well as much up-to-date statistical material. The 1928 Yearbook was the third in a series intended primarily to inform the practical farmer about what is new in agriculture.

Publishing Research Results

The results of fundamental research conducted by the department are published in technical bulletins and in the Journal of Agricultural Research, and popular material is issued in farmers' bulletins, leaflets, and circulars. In the fiscal year 1929 the distribution of farmers' bulletins alone totaled more than eleven and a quarter million copies. Much additional material, both technical and popular, was issued in mimeographed form. Yet the appropriation for all the department's printing, for all its purchases of machinery required in mimeographing, multigraphing, etc., and for the salaries of editors and other employees engaged in informational work amounted to only about 0.8 of 1 per cent of the department's total appropriation. A recent study of the relative effectiveness of various extension methods shows that the printed word is by far the cheapest and quickest method of leading farmers to adopt better farm practices. It would be true economy to increase the department's facilities for informational work.

The Press Service

Public interest in agricultural questions has grown tremendously in recent years, and the press has carried much more agricultural material than previously. Accordingly the department's press service, a division of the Office of Information, has been able to reach a wider reading public with newspaper and magazine articles and other material prepared for daily and periodical publications. A study was made of the agricultural news, editorials, feature material, etc., carried in a number of important daily newspapers in the last seven days of June, 1929, as compared with the amount of similar material carried by the same newspapers in the corresponding seven days of June, 1919. The increase in agricultural news material alone in 11 important papers exceeded 90 per cent. There was also a large increase in editorial and feature material on agriculture and in agricultural market news. Much material supplied by the department's press service was carried regularly in the feature services of the large press associations, and numerous syndicates cooperated in distributing agricultural information. A gratifying aspect of this development was increased accuracy in agricultural reporting and feature writing. During the fiscal year the press service issued for general circulation or for wide circulation in farm journals and trade publications more than 1,000 mimeographed releases, as well as a weekly printed Clip Sheet and many special articles and reviews of department bulletins. It also issued weekly the Official Record, which reports department activities, and numerous statements by the Secretary and other department officials. The press service is in no sense a publicity agency in the usual meaning of that term. Its work is confined strictly to the dissemination of research re-

sults, current economic information, and other useful knowledge. Besides issuing prepared material, the department furnished data for numerous special articles by outside writers. Specialists in the department contributed more than 1,300 articles to various outside publications.

Developments in Radio Service

Outstanding developments took place during the fiscal year in the department's radio service. Chief among these developments was the inauguration of broadcasts through one of the great commercial chain-broadcasting systems. Previously the department's radio programs had been supplied to broadcasting stations in manuscript. In October, 1928, when the National Broadcasting Co. placed at the department's disposal a network of 17 stations for a 15-minute broadcast 5 days a week, it became possible for members of the department to broadcast material in person. Approximately 200 members of the department and 18 guest speakers appeared before the microphone in this broadcasting program. Thus timely material, including crop reports, outlook reports, etc., was brought to the attention of the farmers immediately. Much valuable information on farming and home making was widely broadcast. In January last a broadcast over a network of 38 stations extending from coast to coast gave nation-wide circulation to the department's national outlook report on domestic and foreign business and agricultural conditions. In June a network of 42 stations transmitted a program arranged in connection with the second annual national 4–H club camp. Manuscript radio programs distributed to broadcasting stations in various parts of the country gave additional radio circulation to the department's work. Special service on local agricultural problems was given to cooperating broadcasting stations.

COOPERATIVE EXTENSION

One of the strongest influences in agricultural improvement is the extension service. Through this agency the department and the State agricultural colleges cooperate in demonstrating to farming people the latest and best farm and home practices developed from the experimental activities of these institutions. Extension work is a relatively new educational development; yet recent surveys show that already more than 75 per cent of all farm families have been benefited by it in some manner.

In assisting farmers to attain the standard of living to which they are justly entitled, extension agents very properly devote their efforts largely to the development of programs of extension work which have for their aim a larger farm income. Results of economic studies made during the last 15 years have furnished extension workers with facts upon which numerous State, county, and community extension programs are based. During the year the organization of local farm enterprises, market needs, price trends, and other economic matters were studied to provide the extension agent with a basis for his recommendations for readjustments in the size, volume, or organization of farm businesses. Data issued by the department forecasting the intentions of farmers to plant crops and breed livestock were also largely used.

County agricultural agents advised more than 68,000 farmers regarding the organization of approximately 800 cooperative-marketing associations during the year. Counsel was also given to 2,136 cooperative-marketing associations that were previously organized.

In the Red River Valley of North Dakota, extension agents helped 1,168 farmers to purchase cooperatively 60,000 sheep. Thus, a new farm enterprise was established in a 1-crop farming area. North Dakota also marketed 250,000 pounds of wool cooperatively. In Minnesota, a cooperative purchasing association, organized with the advice and counsel of the extension agent, saved the farmers of Itasca County, $16,000.

Extension effort was devoted to increasing the fertility of the soil through stimulating the use of lime, fertilizers, and green manure. As a result of demonstrations carried on by the extension force during the year more than 300,000 farmers adopted better soils practices for the first time, an increase of almost 27,000 over the number who adopted such practices for the first time last year. The application of lime continued to be one of the outstanding phases of soil improvement in the Central, Eastern, and Southern States. Farmers were helped in testing their soils for lime requirements and in purchasing limestone at reasonable prices. They were also taught the value of using high-analysis fertilizers. In fact, the change in many areas from low-grade to high-grade fertilizers has been due largely to demonstrations and campaigns carried on by the extension service.

Problems Given Special Attention

The problem of producing an increased supply of home-grown roughage for dairy cows again received much attention by extension workers; as did the growing of sweet clover and alfalfa hay and the improvement of pastures as a means of reducing feed costs. The control of diseases, especially tuberculosis of dairy cows and contagious abortion, was promoted through the cooperative effort of county extension agents and Federal, State, and county veterinarians. Better feeding, dairy-herd improvement through testing associations, sanitary production and care of milk, better-sires campaigns, better-breeding programs, and improved construction of dairy buildings were other phases upon which county extension agents centered their efforts during the year. Nearly 500,000 farmers accepted and put into practice the modern and efficient dairy methods taught by extension workers. Similarly, assistance was given to growers of fruit, vegetable, and field crops, to poultry raisers, and to producers of beef cattle, swine, and other livestock.

Farm life is not solely concerned with production, selling, and buying, but with many other features which make living in the farm home more comfortable, more attractive, more enjoyable, and more beautiful. Through its home demonstration agents located in many rural counties, the department comes in direct contact with the farm family, discovers their basic problems, and helps them to work out solutions. Health, for instance, is an important asset in rural contentment and efficiency. Home demonstration agents aided the rural home maker to select and prepare correctly the proper foods to maintain a well-balanced and healthful diet. From the standpoint

of both health and economy, farm people were urged to produce their own supply of eggs, milk, meat, vegetables, and fruit, to maintain proper storage facilities, to can perishable fruits and vegetables, and to home cure their meat. Demonstrations in breadmaking, meat cutting, the preparation of milk dishes, and salad making were given. Women were trained in meal planning, child feeding, maintenance of normal weight in children, the use of corrective diets, infant feeding, preparation of hot school lunches, and the use of a food budget. Instruction was given in sanitation, home nursing, and first aid, and child clinics and dental clinics were arranged in cooperation with local physicians, dentists, and nurses.

Home Improvement Assisted

As a means of conserving the home maker's time and energy and to give her more leisure for relaxation and constructive use, home demonstration agents helped many women to rearrange their kitchens, install modern home equipment, and to rearrange for greater efficiency the sequence of their daily tasks. Business methods were introduced in the farm home. The installation of inexpensive, practical lighting, heating, water, and sewage systems was demonstrated. Farm women were shown also how to improve the appearance of the farmstead, both inside and out.

Especially popular among women and girls were various phases of clothing extension work. These included the making, care, and renovation of clothes, the construction and trimming of hats, home dyeing, making of infants' and children's clothing, repair of furs, and other features which have brought to farm women and girls a better understanding of clothing in relation to health, harmony of color and design, suitability to the occasion, and economical buying.

Farm women took active interest in numerous other community activities seeking to promote the comfort and efficiency of farm families and better their social and economic life. They acted as demonstrators, assumed the responsibilities of local leaders, participated in community programs, attended short courses at the State agricultural college, took tours to neighboring homes demonstrating the best practices, made community exhibits, attended rally days, and sponsored picnics.

In addition to working with adult farm men and women, the extension service, through its boys' and girls' 4–H club work, provided an opportunity for juniors to participate in the benefits of extension activities. Like their parents and neighbors, these young farm boys and girls of 10 years of age and over met in groups, discussed their problems, presented solutions, and planned ways in which they could be of greater service to their communities. More than ever, 4–H club work was recognized by the public as a vital factor in the educational development of the farm boy and girl and an important force in the improvement of rural life.

During the year 46,670 groups were organized into 4–H clubs. The total enrollment was 663,940, an increase of approximately 44,000 over the enrollment in 1927. Of the number enrolled, 67.4 per cent completed all the work assigned to them, as compared with 64.4 per cent who completed the work in 1927. Assisting the co

operative extension agents in training these club members were nearly 60,000 local leaders who voluntarily gave their time and effort to the work. Many of these local leaders were former club members.

Funds for Extension Work

The total funds available for cooperative extension work from all sources during the fiscal year were approximately $22,918,200, an increase of about $2,000,000 over those for the previous year. Approximately $1,500,000 of this increase was in Federal funds and $500,000 in State and county funds. The Capper-Ketcham Act of May 22, 1928, made $980,000 of Federal funds available July 1, 1928, and Congress appropriated an additional $280,000 of Federal supplementary funds. The remainder of the increase in Federal funds was for the employment of agents in counties in the flood-devastated areas. Of the total funds, 39 per cent, or $8,978,363, was contributed by the Federal Government, and 28 per cent, or $6,405,825, was from State appropriations to the agricultural colleges and other State agencies. The remaining 33 per cent, or $7,534,012, came from county appropriations for extension work and from contributions by local organizations and individuals. About 94.5 per cent of all funds used for cooperative extension work in 1929 came from public sources.

The entire State field staff on June 30, 1929, numbered 5,691 persons, an increase of 530 during the year. Of this number 4,170 were located in the counties, of whom 2,452 were in county agent work, 1,167 in home demonstration work, 252 in boys' and girls' club work, and 299 in negro extension work. The work of county extension agents was supplemented by the work by 825 full-time and 212 part-time subject-matter specialists located at the State agricultural colleges. There were 409 supervisors and assistant supervisors and 75 administrative officers and assistants. During the year there was an increase in the field staff of 495 county workers, 2 administrative and supervisory workers, and 33 subject-matter specialists. Of the 495 new county workers added 77 were county agricultural and 57 assistant county agricultural agents, 12 negro county agents, 201 county home demonstration and 25 assistant county home demonstration agents, 17 negro county home agents, 95 county boys' and girls' club agents, and 11 assistant club agents.

Educational Films Distributed

From its motion-picture laboratories the department distributed more than 3,500 shipments of films during the year, which were exhibited to approximately 5,000,000 persons in all parts of the United States. In addition to lending films the department approved requests for the purchase of 298 films. These were bought principally by educational institutions and by foreign governments.

Twelve new films consisting of 26 reels were produced and released during the year. They included Traveler's Toll, Naturalized Plant Immigrants, Home is What You Make It, Under the 4–H Flag, The Master Farmer, How About a Combine, and several films on rust, barberry eradication, land clearing, testing bridges, care of chicks,

and bamboos. Motion-picture films on about 250 subjects covering all phases of farm and farm home life are now in active circulation.

The department showed exhibits to millions of people at 74 fairs and expositions widely distributed throughout the United States during the year. These exhibits utilized the newest devices to impart in an interesting manner the latest and most authentic information on a variety of agricultural subjects. Those which attracted the most attention and which were in the greatest demand during the year were the Milk Factory and the Brood Sow's Rebellion. The exhibits were representations of animals operated mechanically and synchronized with amplified talks.

A special exhibit was prepared for the Ibero-American Exposition at Seville, Spain. This exhibit portrayed agricultural methods used in the United States and featured such subjects as wheat, corn, cotton, tobacco, sheep and wool, poultry, hogs, livestock, sanitation, history and development of the livestock industry, dairying, road building, and experiment-station work. A new motion picture, Naturalized Plant Immigrants, was prepared especially for showing at the Seville exposition, and 25 of the department's films were shown there.

WEATHER FORECASTS

Issuing weather forecasts and warnings for the benefit of agriculture and commerce and of navigation by sea and air has been much facilitated recently by an increased use of radio communication. This has enabled the Weather Bureau to serve the farmers and the rural population and the general public with a promptness never before possible. Long-established services, such as the dissemination of frost warnings, harvest-weather forecasts, warnings of cold waves, and forecasts of minimum temperatures, have gained increased utility. The bureau's forecasts of storms and hurricanes and its flood-reporting service have likewise been more readily disseminated.

The furnishing of weather information for the benefit of navigation on large inland lakes and on the oceans has been carried on by the Weather Bureau for many years. It always has been difficult to get an adequate number of observations from ocean areas. Only by means of weather reports from ships can the conditions prevailing over ocean areas be determined and storm centers located. Marked developments were made in this work during the past year, largely as a result of a better understanding reached among national meteorological services. In 1928 representatives of the Weather Bureau participated in conferences held in Paris and London for the purpose of effecting better international cooperation. Officials of the meteorological services of the principal maritime nations of Europe attended the meetings and made arrangements whereby each country will engage a certain number of ships of its own registry on which observations will be taken daily at fixed hours and transmitted by radio. The ships selected will be equipped with standardized meteorological instruments and long-range radio apparatus.

The organization of such a cooperative service was first begun for the North Atlantic Ocean, and principally for the areas included in

the steamer routes between the United States and Europe. Previously few of the ships plying these routes furnished weather observations by radio. This made it difficult for the Weather Bureau to provide the information desired by shipping interests and to give adequate service in connection with trans-Atlantic airplane and dirigible flights. Frequently only two or three reports a day were available from this immense ocean space. Seldom were a dozen reports received.

Prospects for More Ship Reports

As a result of the new plan nearly 20 ships of United States registry, about 24 British vessels, and 5 French ships now report regularly twice a day. Many more, including those of other nations, will be engaged within a year. All the ships, regardless of nationality, radio their observations to the Weather Bureau in Washington when west of longitude 35°. When the ships are east of that line, the reports are radioed to some designated European meteorological office, which makes them available to other services by broadcast on established schedules. The reports received by the Weather Bureau are made available to European meteorologists by a bulletin broadcast twice daily from the Weather Bureau office through the Navy radio station at Arlington, Va. Besides the ocean data the bulletins contain weather observations made at a large number of land stations in the United States and Canada. In turn a bulletin containing European reports and the ship observations taken in areas east of longitude 35° is radioed from France for the benefit of the United States Weather Bureau. It is planned to extend the international organization to the Pacific and other oceans. At present reports from ships in the southern area of the North Atlantic Ocean, the Caribbean Sea, and the Pacific Ocean are obtained exclusively through arrangements organized by the United States meteorological service.

Aeronautical meteorology has expanded greatly since the passage of the air commerce act, which provides for designation by the Department of Commerce of various commercial airways and airports necessary for the air mail and other air transport. The act also provides that the Weather Bureau shall issue weather information and warnings necessary for safe flying over these courses. Accordingly the basic system of weather reports at 8 a. m. and 8 p. m. is now supplemented by more frequent observations from selected stations. The program, now well under way, provides for a model service along the great transcontinental airway from New York to San Francisco and Los Angeles, a zone about 300 miles broad. Seventy-five stations within this zone make reports at 3-hour intervals to certain major airports or control stations. Through radiobeacon and broadcasting facilities established and operated by the Department of Commerce, pilots in flight, even in thick weather, can pick up weather reports while holding their courses.

This intensified service is now being operated only on the transcontinental line. A similar service will be developed for the important feeder and transverse lines as flying over those lines develops and funds become available.

WILD-LIFE CONSERVATION

Wild life is both a recreational and an economic asset. Its conservation should be considered in all programs for the development of public and privately owned land and water areas. Fortunately this is coming to be widely recognized. Heretofore our dealings with wild-life resources have been wasteful and without forethought. Now a new era is upon us, characterized by a definite policy based on fact-finding through biological research. Public opinion sees the importance of replacing the former enormous waste of wild life by a constructive program of recreation and development associated with wise use. Such a program should emphasize the part that wild life can play in supplementing agricultural production, in adding to land values, and in maintaining opportunities for outdoor recreation. This can be done by increasing the production of wild life and conserving adequate breeding stocks.

Investigations conducted by the Department of Agriculture through the Bureau of Biological Survey have resulted in the accumulation of much valuable information. Continuous research enables the department to deal constructively with the problems of hunting or trapping seasons, bag limits, maintenance of breeding stocks, harvesting the annual crop of surplus wild life, and facilitating the maximum production of game birds, fur-bearing animals, and other mammals consistent with due regard to other interests. The department makes comprehensive studies of big-game animals such as elk, deer, and antelope, to ascertain their numbers, habits, movements, and food requirements. Attention is given also to the diseases and parasites of wild animals and to the influence of predatory creatures on game species. Waterfowl studies include surveys of the numbers, distribution, and migratory movements of geese, ducks, swans, coots, and other birds in this country and Canada. Six thousand volunteers report on conditions observed in waterfowl censuses, or operate trapping stations where, under permit, birds are banded and released as a means of learning about their migrations. Officials of the national parks of Canada, and other agencies in that country and in Newfoundland cooperate in the work.

The Necessity of Research

Research is necessary for the control of injurious species and for the protection of useful animals and birds. Investigations with this end in view have been carried on for nearly half a century. Comprehensive reports have been made on the food habits of more than 200 species and briefer mention of more than 500. This work is the foundation of our advanced bird-protective laws and regulations. In order that the number of beneficial birds may be increased, the Biological Survey studies their food supplies. Information thus gained about the food plants of wild fowl has led to the improvement of their feeding ranges and has solved many problems connected with the establishment of practical bird refuges. Bird attraction through the provision of suitable bird houses has been much studied, with notable results.

It has been demonstrated that by using relatively simple methods farmers can increase the production of game on land suited to

that purpose. Lands can thus be made desirable for leasing to sportsmen, a growing though not yet extensive practice in the United States. In pheasant farming it is possible to rear a small number of birds without the expensive equipment commonly required on pretentious game farms. Further study is necessary to develop better methods of handling small game on the farm. Research is in progress to learn the types of cover most favorable. Study of the diseases of wild birds is important. Such diseases sometimes cause the death of thousands of birds, especially migratory wild fowl, at concentration points. An example was the alkali poisoning of ducks in the Bear River Marshes, Utah. Investigations revealed the cause and indicated remedial measures. Studies of the food habits of animals throw light on their economic significance. It has been demonstrated, for example, that toads are about as valuable individually during their active season as are most birds. Certain species of snakes, at present widely persecuted, have economic value. Some small mammals also are beneficial.

In order to meet more effectively the obligations of the United States under a treaty with Great Britain, the Seventieth Congress passed a bill (45 Stat. 1222) to create in perpetuity absolute sanctuaries for migratory birds. This measure, called the migratory bird conservation act, authorizes appropriations for the examination of areas that might be suitable as bird refuges. It also provides for the acquisition of areas that are found through investigation to be adequate for the purpose of affording perpetual sanctuaries for migratory birds. The act contemplates a refuge-acquisition program extending over a period of 10 years and will result in the establishment of a Federal system of wild-fowl sanctuaries throughout the entire country. The investigational work is in progress. Field parties are making detailed reports on the variety, distribution, and abundance of aquatic and marsh vegetation. Land-valuation engineers are investigating areas found desirable from the biological point of view. This inquiry will indicate the feasibility of acquiring tracts for refuges by purchase, lease, or gift. Other studies necessary under the bill will accumulate additional information about the fly ways of the birds and their food requirements. Data already gained leave no doubt as to the most desirable refuge areas in the various stages of the migratory flights.

The McSweeney-McNary Act

One of the most far-reaching legislative measures taken in recent years for scientific research is the McSweeney-McNary Act (45 Stat. 699). Among other requirements, this act calls for a comprehensive study of fundamental biological facts and principles governing forest wild life. Accordingly the Biological Survey has planned an orderly and sustained investigation on forest fauna. This will seek to determine the kinds of birds, mammals, and other vertebrates that make up the animal population of forest areas.

Though the destructive work of rodents and predatory animals is the most conspicuous relationship between forests and forest fauna, it is not necessarily the most important. Frequently the beneficial activities of wild life overshadow the destructive activities. Hence the research program will pay much attention to the service rendered

by resident and migratory birds and by animals that prey upon destructive insects and rodents.

Gradual upbuilding of the wild life of Alaska is in prospect under the Alaska game law enacted in January, 1925. Alaska's game, fur, and bird life ranks among the most valuable of its products. Trapping is an important industry in most parts of the Territory. In large sections game animals and birds furnish an important share of the human food supply. These creatures were being rapidly depleted in numbers prior to the enactment of the Alaska game law. Some species were threatened with extermination. Work already done under the new dispensation is thought to have checked the decline of the fur and game animals. Continuation of the present policy should permit their increase. Prior to 1925 the fur and the game in Alaska were administered under separate and inadequate laws. The whole field is now under the jurisdiction of the Alaska Game Commission, whose policy is well supported by those interested in the development of Alaskan resources. Though carried on with limited personnel, the commission's law-enforcement work is excellently supported by the courts.

The commission constantly emphasizes the fact that the maintenance of an abundant supply of wild life is an economic advantage to Alaska and brings many other advantges. It has shown that under wise management large portions of the Territory that might otherwise be unproductive can produce valuable annual crops of fur and game indefinitely. Ready acceptance of these views by the people of Alaska has greatly facilitated the commission's work. During each of the past three bienniums, the Territorial legislature has appropriated large sums for stocking areas with valuable fur and game animals. Last year, through cooperation with the Biological Survey, 23 buffalo were shipped from the National Bison Range in Montana to Alaska. Four were put in the Reindeer Experiment Station at College, Alaska, and the rest were liberated near Fairbanks. The herd thrived on the natural feed of the region, withstood the rigors of the winter, and entered the new season in good condition. Increased protection for the big brown bears of Alaska is provided in regulations issued by the Secretary of Agriculture. At the same time landowners and stockmen are authorized to protect themselves and their property against these huge animals.

Fur Farming Well Established

Fur farming is now established in the United States as a permanent agricultural enterprise. It is carried on both as a side line to farming and as a main crop in areas unsuited to cultivation. Fur farms are operated in all sorts of locations, particularly in the cooler latitudes and in mountain country. Some large farms have been converted into fox ranches with hundreds of pens. Many small ranches are on general farms. It is estimated that about 5,000 farmers in the United States and Alaska raise one or more species of fur animals. The majority raise silver and blue foxes. The total investment in fur farming exceeds $20,000,000, and last year fur farms in the United States and Canada produced approximately 80,000 silver-fox pelts. All persons interested in fox farming should carefully consider these facts, so that precautions may be taken to

avoid overproduction and serious damage to fur farming as a permanent industry. Steady development, however, seems desirable. As fur farming progresses—while on the other hand the haunts of wild life are restricted—the tendency of the fur trade will be more and more to obtain supplies from the fur farms.

Domestic rabbit production for both food and fur has developed in the last few years into an important industry in various parts of the United States, especially in California and the Middle West. Rabbit fur is in general demand, and a market exists for rabbit meat in parts of the country, notably in San Francisco, Los Angeles, Seattle, and Portland.

Predatory Animals

Predatory animals and rodents continue to take a heavy annual toll. It is estimated that coyotes, wolves, mountain lions, bobcats, and some stock-killing bears cause an annual loss of more than $20,000,000. This figure allows for the inroads of predatory animals on game and on ground-nesting and insectivorous birds, as well as on sheep and lambs, cattle, pigs, and poultry. In 1916 the Biological Survey began to build up a field force for the control of predatory animals. Predatory-animal districts, each in charge of an experienced leader, were organized in the principal western livestock-producing States. Hunters are not paid on a bounty system, but devote their entire time to the work. Poison campaigns have been increased and made more effective. The result is a large reduction in the number of coyotes and other predatory animals in the sections covered. Livestock losses have decreased correspondingly.

Losses running into the hundreds of millions of dollars annually are caused by ground squirrels, prairie dogs, jack rabbits, pocket gophers, woodchucks, porcupines, mice, and rats. Control of these animals is one of the surest means of reducing the production costs and increasing the profits of agriculture. Much has been accomplished by the department in cooperation with farmers and other landowners. Rodent pests have been exterminated on millions of acres of valuable agricultural land. In the past year nearly 100,000 farmers took advantage of opportunities offered them to wage cooperative warfare on these pests under trained leadership.

Cooperative-Control Program

The Seventieth Congress called for an investigation as to the feasibility of a cooperative-control program extending over five or more years. The investigation was made, and a 10-year program was recommended. The object would be to prevent the constant reinfestation of cleared areas as well as to clear additional areas. Though complete eradication of predatory animals is not practicable, and in some areas is not desirable, a more comprehensive and drastic control policy than that now in force is required.

FEDERAL-AID ROADS

The Federal-aid program of road construction is being advanced as rapidly as the authorized funds permit. In the fiscal year ended June 30, 1929, the addition of mileage initially improved with Fed-

eral assistance amounted to 7,402 miles. This brought the total mileage initially improved since the inception of the Federal policy to 79,796 miles.

A portion of this initially improved mileage, to which aid was granted prior to the designation of the Federal-aid system in 1921, consisted of roads which were not of sufficient importance to be included in the system. To relieve the States of the further necessity of maintaining roads of this character, 485 miles were abandoned as Federal-aid highways during the past year, thus reducing the retained mileage to 79,311. The initially improved mileage has been further reduced by relocations made in the course of stage construction (the making of secondary improvements) by a total of 47 miles; and at the close of the year 1,168 miles was in course of further improvement. Hence the mileage which, for want of a better term, is classified as completed was only 78,096. At the close of the preceding year the mileage similarly classified was 71,074. Hence the net addition of "completed" mileage was 7,022.

Stage construction has become important in the Federal-aid program. It should not be confused with repair or reconstruction, but should rather be considered as deferred construction. The deferment is in accordance with a deliberate policy of construction by stages, a logical answer to the dual necessity for some improvement of a mileage as great as possible, and for the betterment of original improvements to keep pace with increasing traffic. Secondary improvements were completed during the year on 1,988 miles of road.

Increases in Various Types of Construction

The net increases in the several types of construction during the year were as follows: Graded and drained roads, 1,056 miles; sand-clay roads, 562 miles; gravel roads, 1,293 miles; water-bound macadam roads, 189 miles; bituminous macadam roads, 528 miles; bituminous concrete roads, 201 miles; Portland cement concrete roads, 3,101 miles; brick and other block pavements, 48 miles; and bridges, 44 miles; a total of 7,022 miles.

The total mileage classed as completed at the close of the year is as follows: Graded and drained earth roads, 11,667 miles; sand-clay roads, 7,033 miles; gravel roads, 28,991 miles; water-bound macadam roads, 1,616 miles; bituminous macadam roads, 4,845 miles; bituminous concrete roads, 2,194 miles; Portland cement concrete roads, 20,618 miles; brick and other block pavements, 866 miles; and bridges, 267 miles; a total of 78,097 miles.

The total cost of the 7,402 miles of initial improvements and the 1,988 miles of secondary improvements completed during the year was $195,298,168, of which sum $82,736,878 was paid by the Federal Government. These payments extended over the period of between one and two years required to complete the improvements. In addition to the payments made during the last year on these projects, payments were also made on other projects not yet completed. The total actual disbursements of Federal funds to the several States during the year amounted to $82,097,380.

The expenditure of more than $82,000,000 is approximately equal to the disbursements of the past several years. The sum apportioned for each of the years since 1925 has been only $73,125,000 (admin-

istrative expense not included). A higher rate of expenditure has been made possible by a large unexpended balance carried over from earlier years. This balance has permitted construction costing from $80,000,000 to $90,000,000 annually. But the accumulated balance is now exhausted. It is therefore necessary to shape the construction program in accordance with the amount of the annual authorization. Unless the authorization—for the past several years $75,000,000—is increased, it will be necessary materially to reduce the rate of road improvement. A reduction has in fact already occurred. Obligations incurred for new projects during the last fiscal year amounted to only $70,429,896, the lowest amount annually obligated since the fiscal year 1923. For the first time since that year the amount obligated is within the amount apportioned. This curtailment foreshadows a reduced expenditure next year and in succeeding years unless the annual authorization is increased.

Construction Appropriations Authorized

Appropriations authorized for road construction in the national forests have for several years been limited to $7,500,000. Of this sum, $3,000,000 is reserved for building roads and trails required in the administration, protection, and development of the forests. The remaining $4,500,000 is devoted to the construction of main highways extending through the forest areas to form necessary links in the Federal-aid and State highway systems, and to serve communities within and adjacent to the Federal reservations. Such highways constitute a system of 14,165 miles, of which 11,780 miles are in the 12 States of the mountain and Pacific groups and Alaska.

Including the 315 miles of such roads improved during the past year, the total thus far improved is only 4,091 miles. Much of the remainder is totally unimproved and practically impassable by motor vehicles. The current rate of improvement is the maximum possible under the present scale of appropriations, but it falls far short of the progress being made in the improvement of the adjoining Federal-aid and State highways. Forest areas thus tend to remain as barriers to transportation. A similar situation exists with reference to needed connections across Indian reservations and unappropriated public lands.

Federal aid was extended last year in the construction of bridges and their approaches covering more than 44 miles. The year's construction brought the total length of all completed Federal-aid bridges up to 267 miles.

Private Capital in Bridge Building

The construction of major bridges is an expensive undertaking which the State governments have difficulty in financing with current revenues. Faced with an urgent demand for the improvement of thousands of miles of roads, they often find bridge costs burdensome. In consequence, private capital frequently grasps the opportunity to supply the needed structures and charge toll for their use. A survey of all existing toll bridges made two years ago by the Bureau of Public Roads showed that more than half the number

were on the Federal-aid highway system—a condition to be expected in view of the traffic importance of these roads.

It is not sound policy to permit the establishment of private toll bridges at commanding locations on roads improved at great public expense. The ultimate cost to the public exceeds what the cost of public construction and operation would be.

If current State revenues are insufficient for bridge construction, needed funds can be borrowed on the security of anticipated returns in publicly collected tolls. Such borrowing can be done on terms more favorable than those usually available to private builders. Under a recent amendment of the Federal highway act Federal aid can be obtained for bridges financed in this manner. The sum to be raised by tolls can be thereby reduced by half. Whatever method may eventually be adopted, it is obviously desirable that the opportunities for the public construction of bridges should be examined before private construction is authorized.

Standard Signs for Roads

By agreement the highway officials of the several States and the Federal Government have adopted as a standard certain designs for danger and direction signs proposed by a committee of engineers appointed by the Secretary of Agriculture at the suggestion of the American Association of State highway officials. The standard designs are intended for erection on all routes of the United States highway system, which mainly comprises the more important sections of the Federal-aid system. Erection of like signs for similar purposes in all States traversed by the principal interstate routes would promote the safety and convenience of travelers.

In States where these signs have been erected official observation and the praise of travelers indicate that the expected benefits accrue. In several States, however, the plan has not been put into effect. Early action by these States would much increase the value of the improvement, half the cost of which may be paid by the Federal Government.

Planting of Shade Trees

Provision is made for the planting of shade trees in a recent amendment of the Federal highway act. At the request of the State highway departments, Federal funds will be allotted to pay half the cost of suitable plantings. This department will cooperate with State authorities in the selection of suitable varieties and in the planning and arrangement of plantings. Several States have proceeded independently in the planting of shade trees on highways and have effected great improvements at a relatively small cost. As yet, however, no State has called upon the department for financial assistance in such work.

ARTHUR M. HYDE,
Secretary of Agriculture.

FINANCIAL STATEMENT

Expenditures, Department of Agriculture, Fiscal Year 1929

Funds expended and obligated for work under the supervision of the Department of Agriculture conducted during the fiscal year which ended June 30, 1929, including road building, totaled $172,898,690. These expenditures were distributed by organization units as follows:

TABLE 1.—*Expenditures classified by organization units* [1]

Organization unit	General activities (all objects except payments to States and road construction)	Payments to States (exclusive of Federal-aid road funds)	Road construction (including Federal-aid roads)	Total
Office of the Secretary	$1,176,714			$1,176,714
Office of Information	1,136,893			1,136,893
Library	95,675			95,675
Office of Experiment Stations	397,511	$3,840,000		4,237,511
Extension Service	1,960,751	7,162,936		9,123,687
Weather Bureau	2,956,269			2,956,269
Bureau of Animal Industry	[2] 14,349,539			14,349,539
Bureau of Dairy Industry	611,458			611,458
Bureau of Plant Industry	4,620,811			4,620,811
Forest Service	11,648,227	2,610,414	$11,154,207	25,412,848
Bureau of Chemistry and Soils	1,403,007			1,403,007
Bureau of Entomology	2,049,558			2,049,558
Bureau of Biological Survey	1,383,942			1,383,942
Bureau of Public Roads	[3] 826,939	[4]	85,685,774	86,512,713
Bureau of Agricultural Economics	6,074,718			6,074,718
Bureau of Home Economics	147,554			147,554
Plant Quarantine and Control Administration	[5] 4,312,308			4,312,308
Grain Futures Administration	131,359			131,359
Food, Drug, and Insecticide Administration	1,545,134			1,545,134
Seed Loan Office	[6] 5,616,992			5,616,992
Total	62,445,359	[7] 13,613,350	[7] 96,839,981	172,898,690

[1] Expenditures in reports for previous years under the classifications "Regular work," "Special conservation," "Colleges and stations," "Forest Service receipt funds," and "Road construction" are consolidated under the three heads indicated. Expenditures heretofore shown under "Special conservation" for forest taxation and timber insurance studies and for the acquisition of forest lands and lands for the Upper Mississippi River Wild-Life Refuge; all items under "Forest Service receipt funds" except those for road and trail construction and payments to States and Territories, and expenditures under "Road construction" for highway research are included under the head "General activities." The items for "Cooperative fire protection" (exclusive of forest taxation and timber insurance research) and for "Cooperative distribution of forest planting stock," heretofore classified under the head of "Special conservation," the two items heretofore included under "Colleges and stations," and the item for payments to States and Territories under "Forest Service receipt funds" are shown under the head "Payments to States." All expenditures heretofore classified under "Road construction," including those under the Federal-aid road act and supplemental acts (exclusive of amount for highway research) and the Mount Vernon Memorial Highway, and, in addition, the items under "Forest Service receipt funds" for road and trail construction, special road work in flood-devastated areas, and forest road and trail work paid from the general appropriations of the Forest Service, are included under the "Road construction" group.

[2] Includes $3,946,130 paid as Federal indemnities to livestock owners for animals destroyed in connection with tuberculosis eradication, and $5,623,661 for meat inspection.

[3] Includes $314,079 for highway research, paid from appropriation for Federal-aid road construction.

[4] $83,692,540, paid to State highway departments for Federal-aid road work, included under column "Road construction."

[5] Includes $1,268,000 for control of Mediterranean fruit fly.

[6] Includes $5,605,221 for seed and fertilizer loans to farmers in storm and flood stricken areas of Southeastern States, and $11,771 for collection of seed loans.

[7] See Analysis of Payments to States and Road Expenditures.

Analysis of Payments to States and Road Expenditures

An analysis of the figures included in Table 1 as payments to States and expenditures for road construction is given below. It will be noted that the item for Federal-aid road construction appears not only under "Road construction" but also under "Payments to States." It properly belongs in both groups and is repeated in this way so that the total for each group, when taken separately, may be obtained.

(1) *Payments to States*

Office of Experiment Stations:	
Payments to State agricultural experiment stations for research under Hatch, Adams, and Purnell Acts	$3,840,000
Extension Service:	
Payments to State agricultural colleges for extension work under Smith-Lever, Capper-Ketcham, and supplemental acts	7,162,936
Forest Service:	
Payments to States under Clarke-McNary Act—	
(*a*) Cooperative protection of State and private timberlands against fire (exclusive of $59,933 for forest taxation and timber insurance studies, shown under "General activities")	1,148,091
(*b*) Cooperative distribution of forest planting stock	75,188
Payments to States and Territories from national-forest receipts for benefit of county roads and schools	1,387,135
Bureau of Public Roads:	
Payments to State highway departments for road construction under Federal-aid road act and supplemental acts (exclusive of $314,079 for highway research, shown under "General activities")	83,692,540
Total payments to States	97,305,890

(2) *Road construction*

(*a*) Under Federal-aid road act and supplemental acts:	
Forest Service—	
Construction of forest roads and trails	9,080,510
Bureau of Public Roads—	
Payments to State highway departments for Federal-aid road construction (including $1,595,161 for administrative expenses but exclusive of $314,079 for highway research, the latter being shown under "General activities")	83,692,540
Total, Federal-aid road act (exclusive of highway research)	92,773,050
(*b*) Under Forest Service appropriations:	
Construction of roads and trails, under "General expenses" fund	492,094
Construction of roads and trails for States (national-forest receipts fund)	419,179
Construction of roads and trails, under "Cooperative work" fund (contributions from private cooperators)	1,162,424
(*c*) Under special appropriations administered by Bureau of Public Roads:	
Mount Vernon Memorial Highway	76,109
Restoration of roads and bridges damaged by floods in Vermont New Hampshire, and Kentucky	1,917,125
Total, road construction	96,839,981

Expenditures by Types of Activity

The total expenditure of $172,898,690 for the fiscal year 1929, covering all work conducted or administered by the Department of Agriculture, was classified by types of activity approximately as shown in Table 2.

TABLE 2.—*Expenditures classified by types of activity*

Types of activity [1]	General activities (all objects except payments to States and road construction)[2]		Payments to States (exclusive of Federal-aid road funds)	Road construction (including Federal-aid roads)	Total	
	Amount	Per cent			Amount	Per cent
Research	[2] $13,969,275	[3] 22.4	[4] $3,840,000		$17,809,275	10.3
Extension	[2] 2,727,513	4.4	[5] 7,162,936		9,890,449	5.7
Eradication or control	[6] 12,267,299	19.7			12,267,299	7.1
Service activities	[2] 22,526,702	36.0	[7] 2,610,414		25,137,116	14.6
Regulatory work	10,954,570	17.5			10,954,570	6.3
Road construction			([8])	[9] $96,839,981	96,839,981	56.0
Total	62,445,359	100.0	[9] 13,613,350	96,839,981	[10] 172,898,690	100.0
Percentage of grand total	36.1		7.9	56.0	100.0	

[1] The work of the Department of Agriculture may be divided into six general classifications, as follows:

(*a*) Research: Investigations and experiments in animal and plant production, breeding, and improvement, in methods of controlling diseases, insects, and other animal and plant pests, of soil and fertilizer problems, farm management practice, marketing, and crop utilization, and other scientific studies and investigations of the fundamental problems of agriculture, horticulture, forestry, home economics, mete orology, road building, etc., by means of laboratory and field experiments.

(*b*) Extension work: Demonstration and educational work by means of county agricultural, home demonstration, and boys' and girls' club agents and through exhibits, motion pictures, or otherwise, with a view to the dissemination, by direct contact, of the information developed by the experiments and discoveries of the department and the various States.

(*c*) Eradication or control: Direct control or eradication of plant and animal diseases, insects, and other pests, through organized campaigns, either independently or in cooperation with State agencies.

(*d*) Service activities: Includes such activities as the administration and protection of the national forests, the weather service, market news and inspection services, crop estimating, seed loans, and other work of like character for the benefit of the public, not primarily involving research, extension, or the enforcement of regulatory laws and exclusive of road construction.

(*e*) Regulatory work: Administration of regulatory laws, including the food and drugs act, meat-inspection law, plant and animal quarantine laws, migratory-bird treaty act, cotton futures and cotton standards acts, grain standard act, warehouse act, and others.

(*f*) Road construction: Includes construction of the Federal-aid highway system and forest roads and trails under the Federal-aid road act and supplemental acts, the Mount Vernon Memorial Highway, special road work in flood-devasted areas, and forest road and trail work paid for from the general appropriations of the Forest Service, from national-forest receipts, and from funds contributed by Forest Service cooperators.

[2] The "General activities" column includes, in addition to expenditures reported in previous years under the designation "Regular work," the following items listed in past years under the special classifications mentioned below:

Research: $455,969 for (1) forest taxation and timber insurance studies, heretofore shown under "Special conservation"; (2) forest investigative work, under "Forest Service receipt funds"; and (3) highway research, under "Federal-aid road construction."

Extension: $53,481 for cooperation with States in farm forestry extension work under the Clarke-McNary Act, formerly shown under "Special conservation."

Service activities: $1,726,166 for (1) acquisition of forest lands and lands for the Upper Mississippi River Wild-Life Refuge, shown formerly under "Special conservation"; and for (2) improvement, fire protection, brush disposal, and other forestry work defrayed from funds provided by Forest Service cooperators, and (3) refunds of deposits made by users of national-forest resources, under "Forest Service receipt funds."

[3] 8.1 per cent of grand total.

[4] Payments to State agricultural experiment stations under Hatch, Adams, and Purnell Acts.

[5] Payments to State agricultural colleges under Smith-Lever, Capper-Ketcham, and supplemental acts.

[6] Including $3,946,130 paid to livestock owners as Federal indemnities for animals destroyed in connection with tuberculosis eradication, and $1,268,000 for control of the Mediterranean fruit fly.

[7] $1,148,091 for cooperation with States in forest-fire protection, and $75,188 for cooperation with States in distribution of forest planting stock, under Clarke-McNary Act; and $1,387,135 for payments to States and Territories from national-forest receipts funds for benefit of county roads and schools.

[8] $83,692,540, paid to State highway departments for Federal-aid roads, included under co mn "Road construction."

[9] See Analysis of Payments to States and Road Expenditures.

[10] Grand total.

Special Corn-Borer Clean-Up Campaigns of 1927 and 1928

By act of February 23, 1927, an appropriation of $10,000,000 was provided for the purpose of assisting the States infested with the European corn borer in a special clean-up campaign looking to the control of this pest. Complete figures are now available covering expenditures for control operations under this special fund for work conducted during each of the fiscal years 1927 and 1928, as follows:

Fiscal year ended June 30, 1927	$3,867,837
Fiscal year ended June 30, 1928	5,563,317
Total	9,431,154

In addition to the above items, approximately $145,000 of the balance of this $10,000,000 appropriation was used during the fiscal year 1929 for researches on various phases of the corn-borer problem, which amount is included in the total for "General activities" of the department in Tables 1 and 2. Of the remainder of this balance, $250,000 is authorized to be expended for corn-borer research and $50,000 for control operations during the fiscal year 1930, leaving available approximately $125,000 of the $10,000,000 fund for the fiscal year 1931, if reappropriated.

Income from Department's Activities, Fiscal Year 1929

Incident to the department's work during the fiscal year 1929, receipts totaling $9,765,527 were covered into the Treasury and fines were imposed and judgments recovered by the courts amounting to $172,890 in connection with the enforcement by the department of the regulatory laws which devolve upon it for administration and execution, as follows:

(1) *Receipts*

(*a*) Deposited to credit of miscellaneous receipts fund:		
From business on the national forests	$6,299,802	
Contributions from private cooperators, appropriated as a special fund for road and trail construction, fire prevention and suppression, brush disposal, and investigative work on national-forest and privately owned lands	1,831,827	
From other sources	1,037,283	
		$9,168,912
(*b*) Deposited to credit of applicable funds of department:		
Fees collected for classifying cotton, deposited to credit of revolving fund for conducting that work	200,728	
Reimbursement to various department appropriations for expenditures made therefrom	395,887	
		596,615
Total receipts		9,765,527

(2) *Fines*

Fines imposed and judgments recovered by the courts in connection with violations of statutes intrusted to Department of Agriculture for enforcement	172,890
Total income from activities of Department of Agriculture	9,938,417

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REPORT OF THE CHIEF OF THE BUREAU OF AGRICULTURAL ECONOMICS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF AGRICULTURAL ECONOMICS,
Washington, D. C., September 11, 1929.

SIR: I have the honor to transmit herewith a report of the work of the Bureau of Agricultural Economics for the fiscal year ended June 30, 1929.

Respectfully,

NILS A. OLSEN,
Chief of Bureau.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

The work of the Bureau of Agricultural Economics was expanded during the past year along a number of lines. New activities were provided for by legislation, and the service and informational work were broadened by means of increased appropriations. Significant progress was made in the expansion and redirection of research to meet the most pressing needs for information and assistance in readjusting farm and marketing methods to new conditions. At the close of the year work was in progress on 287 projects, each covering a definite problem in the economics of producing or marketing agricultural products.

The Federal Farm Board has recently been set up as a new instrumentality to assist in solving the problems of American agriculture. Evidently it was intended that the board should translate into action the results of service and research. For the formulation of these programs of action, the board must have comprehensive, reliable information on all economic phases of agriculture. Its declared policy is to look to this bureau for such information. The fact-collecting and research activities of this bureau already have been broadened as a result of the board's requests. In fact, in order to make immediately available needful information, the board has indicated its willingness to provide this bureau with additional resources. Among other things, the board has requested the Bureau of Agricultural Economics to establish, as soon as possible, an adequate foreign agricultural service, cooperating with all other departments of the Government, and has indicated its willingness to support this work until such time as permanent provision for it can be made.

The bureau's activities during the past year in no small way have sought to provide information required in the handling of the economic farm problems. Price analysis and its application in outlook and price-situation reports has been further developed. Intensive studies regarding the most effective use of land in areas of low agricultural productivity have yielded encouraging results. Adjustments to the economic outlook and such factors as improved machinery, new methods, and the like have been furthered by investigations in the field of farm management. Increasing attention has been given to studies in the marketing of agricultural commodities, with a view to eliminating uneconomic methods and practices. Particular emphasis has been placed on fundamental research in the field

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of cooperative marketing and assistance to cooperatives in the solution of their problems. The resources of the bureau, as a whole, have been to an increasing degree coordinated and concentrated upon the researches in the fields of general and cooperative marketing.

The first specific appropriation for agricultural outlook work was made for the past fiscal year. Previous to that time such a report had been prepared by members of the staff who were engaged in other work. The new appropriation made possible the employment of additional specialists to devote their entire attention to gathering, assembling, and analyzing data bearing upon the agricultural situation. Much statistical and analytical work remains to be done before the bureau will be in position to meet fully the demands for economic information needed as a basis for intelligent planning of farm operations. The outlook report for 1929, which was issued in February, was enlarged to cover in condensed form the results of analyses of all available data for 38 of the most important farm products or groups of products. These data covered both domestic and world conditions of supply and demand and pointed out the probable future trends in production and prices. Farmers were advised as to opportunities for profitable expansion of certain activities and warned against overexpansion of others. A large number of State agencies cooperated with the bureau in this work and published further detailed information for the benefit of their particular States and sections and used it in making specific recommendations for reduction or expansion of acreages of various crops.

An increasingly important factor in the preparation of outlook reports is the information on agricultural conditions in foreign countries. All available data are obtained through the Consular Service, the International Institute of Agriculture, the Department of Commerce, foreign correspondents, and the bureau's foreign marketing specialists as a basis for estimating the probable future trends of production and consumption of agricultural products.

Progress has been made in developing a crop-reporting service for foreign countries through the bureau's foreign representatives and other agencies. Effort has been made to obtain information with regard to agricultural resources of foreign countries, prospective developments in foreign production, conditions which affect the demand in foreign countries for American agricultural products, and other data of vital interest to American farmers. This information has been combined with the crop and livestock reports of the bureau and has furnished the basis for appraising world conditions for agriculture and the probable future competition which American agricultural products must face.

Studies of farm taxation yielded valuable results. These studies showed the need for shifting a part of the burden from agriculture to other industries which are better able to carry it through new forms of taxation or revisions in the present taxation systems. The facts brought out pointed also to the possibility for greater economy in the use of public funds.

Studies of agricultural credit have disclosed that local money shortages hamper farmers' operations, and that farmers often pay exorbitant rates for credit when they buy goods on time. Recommendations have been made that farmers should discontinue their store-credit operations as far as possible, and establish connections with local banks where credit may be had at lower rates of interest. Much research and educational work needs to be done in order to bring about wise use of credit by farmers and in order to make it possible for them to obtain such credit at reasonable rates.

Improved methods have been devised for estimating acreage changes, and in forecasting crop yields. Statistical research applied to crop estimating is a new field relatively, but the work thus far accomplished has resulted in greater accuracy in the reports and in economy in handling the large volume of necessary data. Special studies have been made to meet new needs. A study of the factors affecting the size of apples in the Hood River apple district of Oregon, for example, was completed during the past year, and the results will be used by the cooperative apple association in the valley in making their sales contracts during the current year.

The first full year's work was completed under the act providing for estimates of the grade and staple length of the cotton crop and of the carry-over on August 1. The reports issued were of great interest to cotton

producers and others, since they made available for the first time adequate information on the quality of cotton on hand and of the current crop. As an illustration of the value of the service, it was shown that approximately one-sixth of the 1928 crop was untenderable on future contracts, the greater part of this quantity falling short of the required seven-eighth inch length. More than one-half of the total 1928 crop was of seven-eighth inch length or shorter. Experiment stations and other State agencies are using the reports of the department to guide them in their experimental and educational work.

A new section has been established in the bureau to handle problems relating to the tobacco crop. Although this crop has a very high monetary value, practically no economic research has been possible up to the present time, and the information made available on production and supplies had been inadequate. Under the provision of the tobacco stocks and standards act, approved January 14, 1929, quarterly reports on stocks of tobacco have been issued. These reports segregate the tobacco by types and show a separation between new and old crops. The act authorizes the promulgation of official standards, among other provisions. In addition, the agricultural appropriation act provided for the inauguration of a grading service for tobacco similar to those for fruits and vegetables and other crops. Arrangements were being made at the close of the year for the inauguration of the service in cooperation with various agencies.

The work of preparing and demonstrating standards for farm products has gone steadily forward, as well as educational work in bringing about better methods of handling and marketing. Although the bureau has been working in this direction for a number of years, only a small percentage of farmers market their products under standardized grades. The farmers' cooperative associations are bringing about a great improvement in this respect, however, and State agencies throughout the country are cooperating with this bureau in bringing about the general use of uniform standards for farm products. Much educational work has been done in reducing waste and losses in the marketing of perishable farm products, through adopting improved practices. The bureau works continuously on the development of more efficient methods and gives advice and assistance to farmers putting new methods into effect.

The United States grain standards act has been in operation since 1916 and has come to be a very important factor in the marketing of grain. It has seemed desirable to make an impartial study of the operation of this act; consequently, late in the year a committee was appointed which is now making a survey of the entire field for the purpose of ascertaining what steps, if any, should be taken to improve the service. It is expected that the committee will report upon its findings within the next few months.

A greater demand than ever before was noted in the various service activities of the bureau. A total of 266,831 cars of fruits and vegetables was inspected and certificates issued covering quality and condition, as compared with 243,262 for the previous year, and inspections of other products increased proportionately. An experimental grading service for rice was inaugurated in cooperation with the States of California and Texas. Federal grain supervision offices passed upon the grade and issued certificates for 84,135 lots of grain, some of which involved large quantities of grain shipped in bulk by vessel or barge, as compared with 80,618 the previous year. The boards of cotton examiners classified 446,181 bales of cotton tendered for delivery on future contracts, which is the largest quantity tendered for a number of years.

The market news service was expanded by extending the leased wire telegraph service to Montgomery, Ala., and to Sioux City, Iowa, and preparations were being made at the close of the year to extend the leased wire to Portland, Oreg., Seattle and Spokane, Wash., Boise, Idaho, New Orleans, La., Cleveland, Ohio, and Detroit, Mich., and to provide connection at several additional points where State officials will receive the information and give it wider publicity for the benefit of their localities. A greater volume of current market information was disseminated during the past year than ever before.

Detailed information and specific results of the bureau's work will be found in the bulletins and periodicals which have been published. The statements in this report which follow under each of the major divisions of the bureau, outline in general the scope of the work which has been undertaken and some of the more significant results.

DIVISION OF FARM MANAGEMENT AND COSTS

C. L. Holmes, *in charge*

The work of the Division of Farm Management and Costs is concerned with the economic problems of the individual farmer and with the business organization and management of the individual farming units. Its research work is concerned with the problems of determining the use to which the farmer shall put his resources in terms of cropping programs and livestock systems. It points out the best and most efficient financial and technical organization of agricultural business units and the most efficient methods to be followed in the production programs. It is concerned with studying the efficiency of agricultural production, and with the price outlook as it affects the farmer's production program both from a long-time point of view and from the point of view of year-to-year modification.

That the division may function to best advantage in the research field, studies have been made of the broader aspects of agricultural development, both as a whole and by regions and localities. The historical and geographical differentiation to be found in farming and the range in type of farm organization at any given time and within any given region are of outstanding importance in determining the best organization and management of farms, and special attention has been given to these subjects.

TYPES OF FARMING

Studies looking toward the measurement of shifts in types of farming were continued. Data from the last three census reports have been analyzed, and changes in the relative importance of the different crops and classes of livestock in the different counties have been mapped for the entire United States. These maps provide an accurate picture of the changes in the agriculture of the different areas and are of fundamental use in determining systems of farming which are best adapted to the physical and economic conditions prevailing in each area.

Detailed analyses of types of farming were conducted during the past year in cooperation with eight State agricultural colleges and experiment stations. These studies were completed in South Dakota and Kansas, and similar studies are nearing completion in Michigan, Texas, Minnesota, Indiana, and Nebraska. These detailed studies are particularly helpful in supplying agricultural workers with definite knowledge upon which to base programs for improvement. In North Dakota, Oklahoma, South Dakota, and Kansas, where the studies have been completed, the results were used to good advantage last year in interpreting the national outlook to local extension workers and to farmers in terms of the conditions prevailing in the different localities in each State.

THE APPLE INDUSTRY

Particular attention was given to a study of the present status and future outlook for the apple industry. Tree plantings and removals of different varieties and prices received for the different varieties, grades, and sizes in the major apple-growing districts were studied.

Bulletins were issued in cooperation with the Utah and Arkansas agricultural experiment stations which contained information on the cost of producing apples with particular reference to the different varieties. They pointed out means whereby profitable adjustments might be made in the farming systems of the apple areas studied. Bulletins on the factors affecting the price of apples were prepared in cooperation with the agricultural experiment stations of Oregon and Idaho. These publications pointed out the importance of producing certain varieties and of certain grading and sizing practices from the standpoint of increasing the farmers' returns. Similar studies are being made in Washington and in the Cumberland-Shenandoah area of Pennsylvania, Virginia, and West Virginia in cooperation with the State experiment stations.

RETURNS TO STRAWBERRY GROWERS

Study of the factors which affect returns at New York City to strawberry growers was continued in cooperation with the Arkansas Agricultural Experiment Station. Annual, weekly, and daily supplies in New York are being analyzed for the purpose of showing the quantities of strawberries that New York City will take at various prices. Variations in the prices of berries from the different producing centers are being studied, and New York City's preference for berries from the different parts of the country as determined by the prices paid

is being considered. This study will yield facts of value to southern and eastern strawberry growers. A study was undertaken in cooperation with 10 Southern and Eastern States to determine the place of strawberries in the organization of the farm and the principal factors which affect the returns received by strawberry growers. Particular attention is being given to the practices and costs of producing strawberries in the various competing districts and to determining the possibilities of adjusting production to demand.

THE EASTERN GRAPE SITUATION

For some years past conditions in the grape industry of the United States have been unsatisfactory. As a result of low returns to eastern grape producers, this bureau, in cooperation with the agricultural experiment stations of Missouri, New York, Michigan, and Pennsylvania, undertook an economic study for the purpose of providing a basis upon which eastern grape producers may make plans for the future constructive development of the industry.

This project includes an analysis of the present condition of vineyards, recent plantings, removals, and care now being given to the vines. Details of operations, such as soil building, spraying, pruning, thinning, grading, packing, and disposal of grapes with final reference to quality, costs, and prices are being studied. The farm-management work will be coordinated with the results of investigations by the bureau of the consumption and marketing of grapes. The final aim of the research is to indicate how the eastern grape farmers may improve their farm organization, production, and marketing practices, and how better to adjust their production to market requirements.

THE PECAN INDUSTRY

At the request of the National Pecan Growers Association a study of the pecan industry was undertaken in cooperation with State agricultural colleges and experiment stations. Information was obtained relative to the labor, power, materials, and equipment used in production, the cost of the various elements of production, and the price received for varieties and grades of pecans sold by different methods. The results of this investigation will be presented in printed form with results of other phases of the study now being made by other divisions of the bureau of the future trends of production and of marketing practices. The final aim is to determine and to interpret the national economic factors that affect the pecan industry in each of the various areas so that the growers may have a better understanding of the future of the industry and of the practicability of effecting economies in order to meet future conditions.

INFLUENCE OF WINTER LEGUMES ON CROP PRODUCTION

In cooperation with the Bureau of Plant Industry a study was made in Georgia, Alabama, South Carolina, and North Carolina to determine the extent to which farmers are using winter legumes in their system of farming and the economic benefits derived from this use. The study indicates that where these crops are plowed down for corn the yield of corn is increased from 5 to 30 bushels per acre in average seasons. Exceptions were found when the stand of corn was poor or when the winter legume did not make a satisfactory growth. Indications are that the results of plowing down legumes for cotton are not as uniformly good as for corn; yet there were numerous cases in which the results were excellent.

The time and manner of sowing the legume seed, the inoculation of the seed or soil, the use of fertilizer, the time of plowing down the legumes, the date of planting the subsequent crop, and the time elapsing between plowing and planting affect the returns from the following crop. The results of this study have a particular significance in studies of profitable systems of farming.

ECONOMICS OF HAY PRODUCTION

Steady decline in the number of hay-consuming animals on farms and replacement of draft and driving animals with automobiles and trucks in cities has resulted in a decreased demand and price for hay. This condition makes it essential that producers of market hay seek means of reducing their production costs. With the view of aiding hay producers in reducing their costs a set of lantern slides entitled "Equipment and Practices that Reduce Costs in Hay Making," together with explanatory notes, was prepared for the use of extension workers in sections in which the production of hay for market is an important enterprise. This series consists of 62 slides illustrating the

latest labor-saving hay-making equipment and practices. Farmers' Bulletin 1615, entitled "Hay Stackers and Their Use" was submitted and is now in press. This bulletin presents all essential information on the use of the various makes of hay stackers, and is of especial value to farmers in the East and South, where most of the hay stacking is done by hand.

SWEETCLOVER IN THE CORN BELT

An economic study of the production and utilization of sweetclover on Corn Belt farms was undertaken in cooperation with the Bureau of Plant Industry and the experiment stations and agricultural colleges of several Corn Belt States. Sweetclover is rapidly becoming one of the most important leguminous crops in the Corn Belt. It is important for soil improvement, for pasture, and, under certain conditions, for a hay crop. As the European corn borer continues to spread, sweetclover is likely to play a more important part in the systems of farming of the Corn Belt. Results of this study will be useful in determining how and to what extent sweetclover may be used in making adjustments in the farm organizations on farms on which the corn borer becomes destructive.

BROOMCORN PRODUCTION

In cooperation with the Bureau of Plant Industry and the agricultural colleges and experiment stations in the States of Illinois, Oklahoma, and Kansas a study was undertaken to determine the present condition and future outlook for the broomcorn industry. The Bureau of Plant Industry paid particular attention to the agronomic phases of broomcorn production, and this bureau considered the economic aspects. Demand for broomcorn brush is limited. When production is light prices are good and the growers make money, but the industry is easily overexpanded.

Each of the principal broomcorn areas can shift from broomcorn to other cash crops without great difficulty; therefore, one of the main objectives of the farm-management study is to determine the place of broomcorn in the system of farming in each of the important districts under different price conditions. This involves a study of production costs and practices, influence of variety and quality of broomcorn brush on price, and comparison with similar data regarding other crops.

SYSTEMS OF HOG PRODUCTION ON CORN-BELT FARMS

The study of the economics of pork production on Corn Belt farms was continued. Particular attention was given to the place for the different systems of pork production in different parts of the Corn Belt as determined by the size of farm, quantity of corn produced, climatic conditions, and other crops and livestock in the farm organization. Changes that occur in the production program when hogs are low in price and when they are high in price were given attention. The final aim of this study is to determine the best systems of hog production in the different type of farming areas of the Corn Belt States and the variation that can be made in each to meet prospective changes in hog prices.

BEEF-CATTLE PRODUCTION IN WEST VIRGINIA AND SOUTHWESTERN VIRGINIA

Profitable utilization of grass is the main problem of farmers in the cattle-producing districts of Virginia and West Virginia. Beef cattle still offer the best means for converting this grass into money, although dairying is gaining headway in several parts of the area. One problem here is a revision of production methods to meet more nearly the changes in consumer demand that have taken place in recent years. This study involves the bringing together and interpretation of experimental and other data for the purpose of indicating desirable systems of beef-cattle production and farm organization for different parts of the area.

RANGE-CATTLE PRODUCTION

Studies in the important range-cattle producing areas were continued in cooperation with the Bureau of Animal Industry and the State experiment stations and extension service. As these studies are concluded in a given district, definite methods of range-cattle production and ranch organization are worked out for each part of the district covered. Recommendations are made as to changes that ranchmen operating under different sets of conditions may make to increase their returns. Plans have been made to carry this material and the outlook material on beef cattle, including the probable demand for feeder cattle, back to the ranchmen in these districts in a way that will help them to reorganize their business.

HOG PRODUCTION IN PEANUT DISTRICTS OF ALABAMA AND GEORGIA

The study of hog production is an outgrowth of the study of livestock possibilities in the southeastern coastal plains, the results of which have been recently published in Technical Bulletin 127. For the area as a whole the lack of good native pastures limits the extensive production of cattle and sheep. An exception is found in the black prairie belt of Alabama and Mississippi, where excellent pastures can be developed. Farmers' Bulletin 1546 treats in detail the systems of farming which offer good opportunities in this district.

The outstanding district for hog production is located in southeastern Alabama and southwestern Georgia, where peanuts do well. Profitable hog production in this district depends to a large extent on carrying hogs economically on grazing crops during the summer until the peanuts are ready for hogging in the fall. The system of grazing and, to some extent, the system of finishing depends upon size of farm, other crops grown, labor supply available, etc. Plans for this district are being worked out showing definite systems of hog production to fit these conditions and the farm organizations that seem likely to give the greatest return during the next few years.

TREND OF POULTRY INDUSTRY

Effort has been made to bring together and to analyze the economic information available in the department on the factors which affect the economic welfare of the poultry industry. A report has been prepared consisting largely of maps, graphs, and tables, with explanatory text which deals specifically with factors affecting the long-time and the short-time changes in egg prices, the cause and significance of price differences as between various grades of eggs, and the economic and other factors that have contributed to the marked changes in egg production and marketing since the World War. This report will be of unusual interest to commercial poultrymen and will serve as an excellent basis for Federal and State economic studies of poultry farming.

ECONOMICS OF BEEKEEPING

Study of apiary operation and management was continued during the year in cooperation with the Bureau of Entomology. Detailed records of labor used, expenses, and production were kept by 40 commercial beekeepers in the intermountain States. Conditions for honey production were variable in 1928, and although some apiaries were profitable, returns from others were very unsatisfactory.

The study indicates that the relation of practices to yield per colony is the most important single factor affecting earnings of the operator. Large apiaries usually have more complete equipment and make better use of the labor actually spent in caring for bees and honey. Yet the wide distribution of bee yards necessary to handling a large number of colonies requires much time for transportation expenses, which tends to limit the size of one business unit. Indications are that many of the economies of operation and management are applicable to apiaries of different sizes.

THE COMBINED HARVESTER-THRESHER

The study of small-grain harvesting and threshing methods, and particularly of the combine method, begun in the Great Plains States in 1926 and continued in the Corn Belt and Eastern States in 1927, was extended to include North Dakota and Minnesota in 1928. The work was done in cooperation with the Bureaus of Plant Industry and Public Roads, the agricultural experiment stations, and the Grain Division of this bureau.

The work was especially valuable in that it included a study of the newly developed windrow and pick-up attachment for combines in an area where, because of weeds and the uneven ripening of grain, straight combining does not always prove satisfactory. Information obtained shows that in straight combining, 5 to 10 days should elapse after a crop is ready to bind before harvesting with the combine begins, but the 1928 study showed that, by using the windrow method, harvesting can begin as early as when the binder is used. It was determined that the cost of windrowing is somewhat higher than the cost of straight combining, but that the loss of grain is less. With the publication of the data obtained in 1928, which are now in manuscript form, all of the results of these different studies will be available to grain growers in printed form.

EUROPEAN CORN BORER

The continued advance of the European corn borer into the major corn-producing area makes it necessary for

farmers in that area to consider adjustments in the present farm organization to meet the situation effectively when the corn borer becomes destructive. A study was inaugurated during the year in cooperation with the Indiana Agricultural Experiment Station to determine the most successful systems of farm organization and management. The extent to which different methods of cornstalk utilization and disposal are now being practiced under varying sets of conditions will be determined. Changes in crop rotations, livestock combinations, and types of equipment are being considered, as well as farm practices that will utilize cornstalks in ways that will give greater financial returns, economically conserve soil fertility, and most effectively control the European corn borer.

A study was undertaken for the purpose of ascertaining the possibility of substituting other crops for part of the corn acreage. Effort was made to determine the present outlook for such crops as sugar beets, canning crops, tobacco, and others which might be substituted for corn, and to determine the relative profitableness of producing these crops in comparison with corn under corn-borer conditions. It is important to determine the extent to which farmers can afford to increase their cost of corn production by control measures and continue to grow corn in preference to other possible substitute crops. The problem is not the same in the different districts of the Corn Belt States. The problem of corn-borer control varies in intensity as the acreage of corn produced per farm varies. Thus, in certain parts of the Corn Belt most of the corn acreage grown per farm is required for the silos, and under those conditions the clean-up problem is of minimum importance. In other districts the corn acreage per farm is large, and much of the corn is husked from standing stalks. It is in such districts that the farm-management problems under corn-borer conditions are most important.

FARM RECORDS AND ACCOUNTS

Studies of farm organization and management by means of detailed farm records were conducted in cooperation with the State colleges of agriculture and experiment stations of 12 States in selected farming areas. Data are obtained from daily records showing the amounts of man labor, horse work, fertilizer, and other factors used in crop prduction and the amounts of man labor, horse work, feeds, and other factors used for the production of livestock. The records also show the financial progress of the farm as a whole. Data from these studies show how successful farmers have worked out profitable practices, and indicate the causes for failure on unprofitable farms. The data, with supplementary information on local prices, crop yields, and trends of production, are used in outlining systems of farming that seem to offer the best opportunities for profits under conditions generally found in the area.

A bulletin was published in Texas showing probable returns from different systems of farming in the black waxy prairie belt of Texas. This bulletin points out the extent to which livestock may be profitably included in the system of farming. Bulletins reporting the results of a study in the Jackson Purchase area of Kentucky form the basis for an extension program to promote better systems of farming in a section where tobacco is being replaced by other enterprises. In Iowa a series of bulletins reporting the findings of a completed study on profitable systems of farming is in preparation.

COST OF PRODUCING STAPLE CROPS

Cost-of-production studies of corn, wheat, oats, and cotton, were continued. Reports from farmers located in many parts of the country were analyzed and the results published. This project is continued from year to year for the purpose of making available data which will indicate general changes from year to year in production costs. For the farms reporting, the 1928 corn-production costs averaged 3 cents per bushel more than did the costs of the previous two years. The 1928 cost of producing wheat averaged 6 cents per bushel more than the average cost in 1927. Production costs of oats were generally less in 1928 than for the previous year. Cotton-production costs tended to be only slightly more in 1928 than they were in 1927.

FARM RETURNS

A study of statements submitted by voluntary reporters of the financial results of their own farms for 1928 yielded the following information: The average return of $1,334 shown by 11,851 owner operators for 1928 was higher than in any of the years

1922–1927, in which farmers from the same general list have reported their returns. The return of $1,334 per farm in 1928 was made by farms averaging 284 acres in size, representing an investment of $15,417 at values current on January 1, 1928, and consisted of $1,090 excess of cash receipts over cash outlay for current operating expenses and an increase of $244 in the inventory of crops, livestock, machinery, and farm supplies.

The farm family had food produced and consumed on the farm, the estimated value of which on the farms reporting the item was $269, and fuel and house rent, the values of which were not reported. Interest averaging $202 paid on indebtedness and outlays for improvements averaging $126 were not included in the computation of current cash operating expenses.

Improvement in average returns in 1928 as compared with returns from the farms reporting in 1927 was shown for the three central geographical divisions. In the western division the average difference between cash receipts and cash outlay for current operating expenses was larger than in 1928, but inventory increases were much smaller; in the North Atlantic and South Atlantic divisions the returns were materially smaller than those reported for 1927. Sixty-five per cent of the reports for 1928 showed returns less than the average, $1,334; half the reports showed more than $891, and half showed less. Slightly less than 9 per cent of those reporting showed net losses from operations in 1928, as compared with 14 per cent in 1922 and 10 per cent in 1925, the best previous year of the period covered by these reports. About three-fifths of the returns have fallen each year in a group ranging from 0 to $1,499; the largest single group has been that ranging from 0 to $499.

LARGE-SCALE FARMING

A study of large-scale farming has been conducted in the Corn Belt States for the purpose of determining the outstanding advantages and disadvantages of large-scale farming when operated from one central unit and with hired labor exclusively. The study indicates that the importance of the management factor upon the success or failure of a large-scale farming organization can scarcely be overestimated. Although there are indications that large-scale operations have advantages in efficiency of operation, some of the economies often claimed for large-scale farming can be obtained on smaller farms with proper management.

One of the characteristics of the large-scale farming organization is the tendency toward a high degree of specialization. Examples of specialization and coordination of farming with other business are a hog farm operated in connection with a packing plant; a farm producing green produce for a canning factory; and large-scale feeding operations in connection with by-products from canning factories.

A part of the growth in large-scale farming has been the result of large numbers of farms coming into the hands of banks and insurance companies during the agricultural depression. A part has come about as a result of the formation of large-scale farming organizations for the purpose of commercializing agricultural production. Various methods have been used in organizing units for large-scale operations. Plans are being laid for a reconnaissance study of the entire field of large-scale farming.

FARMING IN THE APPALACHIAN HILL LANDS

Much of the farm land of the Appalachian Plateau area is rough and broken and is not productive. Farming is carried on under adverse conditions, and the incomes are comparatively low. Thousands of families live on such farms and are making a meager living, either from the farm alone or from the farm and employment off the farm. In cooperation with the State agricultural experiment stations, studies are being made of the farming in Appalachian Plateau districts of North Carolina, Kentucky, and Tennessee that the more profitable systems of farming may be brought to light.

FARM BUDGETING

Studies were continued in cooperation with State colleges of agriculture in Kentucky, North Carolina, North Dakota, and Minnesota in which definite farm plans for the coming year are worked out with farmers. Accounts kept by farmers during the previous year are analyzed, and suggestions are made for the improvement of the next year's operations. Adjustments are suggested, when the outlook for a particular product indicates that the farmer can adjust his system of farming with good chance for success.

The farm plans are the result of budgets carefully worked out and compared. The results of each year's op-

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erations are then compared with the results that would have been obtained through various modifications of the year's business, as shown by the budget statements. In this way data are obtained which are used as a basis for modifying conclusions from records formerly obtained and for testing the soundness and practicability of the suggestions.

REORGANIZATION OF FARMS

The development of more profitable farm organizations for farmers in the dark-tobacco belt of Virginia was continued in cooperation with the Virginia extension service. Changes made in the farming systems as a result of recommendations made by the department have resulted in increasing the farmer's earnings. Thus, in 1927, the farmers who followed the recommended changes in their farm organizations averaged $1,158, as compared with $773 in 1922, an increase of about 50 per cent. On each of the farms included in the organization study the 1927 earnings were higher than the 1922 earnings, although tobacco prices declined more than 40 per cent during the period.

In general, these farms have been reorganized so that tobacco plays a less important rôle in the farmers' incomes. This change was made necessary because of lower prices for certain types of tobacco. The farmers who changed their plans to meet the situation have increased their livestock, especially poultry, hogs, and dairy cows. They have only their best lands for tobacco, and thereby improve the quality of the crop. The major part of their increased earnings has come through the expansion of other enterprises.

In cooperation with the State agricultural experiment stations, organization studies were made in Cache County, Utah, Salt River Valley, Ariz., and in the Elephant Butte project of New Mexico. These surveys, together with information from other sources, served as a basis for indicating incomes that can reasonably be expected from different organizations.

This information was placed before the farmers by means of economic conferences in each territory at which committees of farmers met with a representative of the agricultural college to consider the available facts. On the basis of these facts recommendations were drawn up by each committee as to the desirability of increasing or decreasing the acreage devoted to each of the various commodities in question and as to the best production practices known.

Careful consideration was given to the results of the farm-management survey, the farm budgets which had been prepared on the basis of these surveys, and the information available regarding the outlook for the products raised in the territory. The farmer members of the committees freely gave their judgments on the practicability of the plans presented. After making some changes in them the committees offered definite recommendations as to the farm organizations and practices which seemed best suited for a satisfactory standard of living on different-sized farms under the price relationships that are likely to prevail during the next few years.

A summary of the results of the Cache County economic conference was published by the Utah Agricultural College. Detailed manuscripts have been prepared which give the results of the surveys and conferences held on the Salt River Valley and the Elephant Butte projects. In the wheat-farming area of eastern Washington and northern Idaho, a study of profitable farm organizations is now under way in cooperation with the Washington and Idaho Agricultural Experiment Stations.

In the low hills in southwest Arkansas a study of farm organization, carried on in cooperation with the University of Arkansas, is nearing completion. This study shows that the most profitable farm organization in this locality is the one which is built around cotton as the major enterprise, with the fullest utilization of the time of the farmer and his help coupled with efficient methods of production.

LOCAL APPLICATION OF OUTLOOK INFORMATION

Continued effort was given to the use of outlook information in determining short-time and long-time adjustments which farmers could profitably make in their farming plans. The outlook reports issued by the bureau have been interpreted in terms of State and local problems in order that the information might be directly applicable under different conditions prevailing in different parts of the country. The localization of the national outlook information has been carried on in direct cooperation with State and local agencies. The bureau has been active in cooperating with these vari-

ous agencies in placing the localized information before groups of farmers through annual or semiannual outlook meetings. The work has been well received, and much interest has been displayed in the information presented and in the significance attached to the outlook work.

DIVISION OF CROP AND LIVESTOCK ESTIMATES

W. F. Callander, *in charge*

One of the most important developments in the Division of Crop and Livestock Estimates has been the expansion of research work and the practical application of the results, (1) to the better handling of sample data used in the determination of acreage changes and numbers of livestock, and (2) to forecasting crop yields from weather data, as well as from condition and other factors. The quality of many of the reports issued has been materially improved as a result of the research work.

Rapid progress has been made in the field of statistical research as applied to crop-forecasting problems. This research has been under way only a relatively short time, but it is already resulting in greater accuracy in the estimates and forecasts and in a higher degree of efficiency in the handling of the necessary data. Research has been developed along two well-defined lines. The first covers the problems involved in obtaining basic data and making estimates therefrom, which may be termed sampling in the broadest sense of the word. As sample data form the bases of practically all the estimates and reports, it was found essential that all of the technical workers should have a thorough knowledge of sampling theory and practice as it applies to the many sampling activities of the division. Through a series of special conferences, extending over three years, practically all of these workers, both in Washington and in the field, have received special instruction in statistical methods and the application of these methods to crop-forecasting problems.

The second field of research deals with the problems of measuring fundamental relationships such as exist between weather and crop yields over a series of years; or economic factors on the one hand and changes in acreage or production of livestock and livestock products on the other; and the use of these relationships as a basis for forecasting agricultural production. Objective methods are being developed to supplement the present methods of forecasting, which are largely subjective in character. Already some interesting studies have been made. In New England, for example, the field statistician found remarkably close relationship between June and July rainfall and the yield of potatoes and has developed a forecasting formula which was used last year with gratifying results.

Practically all of the reports issued covering crop acreages and numbers of livestock are based on reports from individual farmers, each of whom reports for his own farm. The introduction of the use of these individual-farm questionnaires in place of the judgment or opinion inquiries which had been in use sinoce 1866 has been a long step toward increased accuracy both in estimating crop acreages and in estimating numbers of livestock.

Individual-farm questionnaires are sent out several times a year. The first set of schedules is mailed out in March and calls for information concerning the farmers' intention to plant spring crops. These schedules include questions as to the acreage of various crops grown the previous year and the acreage they intend to plant for the current year, from which the change is calculated. Nearly 250,000 schedules of this kind were sent out. In June another similar questionnaire is sent out to about the same number of farmers asking for the acreage in various crops for the previous year and the acreage planted in the current year. This questionnaire affords the principal basis for the preliminary estimates of acreage planted, which is issued in July. In September nearly 1,000,000 cards are distributed through the rural carriers, on which the farmers are asked to report the acreage for the current year only. These cards constitute the principal source of information for the December estimate of acreage harvested.

In addition to the individual-acreage inquiries, two individual farm inquiries are made concerning livestock, through the rural carriers, one in June and one in December, and one questionnaire is sent out by mail in January. The June inquiry covers swine and sheep; the December inquiry covers all classes of livestock.

It has been found that the data secured from the individual farm questionnaires can best be handled in the field offices by statisticians who

are familiar with local conditions. For this reason the handling of all of the inquiries relating to acreage and livestock numbers has been turned over to the field offices. The interpretation of the data is now made largely in the field offices by the statisticians in charge, in conference with statisticians from the Washington staff. Each field office is visited by a member of the crop-reporting board at least twice a year, once in June to review the preliminary estimates of acreage issued early in July, and again in November, to review the results of the fall acreage survey made through the rural carriers. A number of offices are also visited in January in connection with the livestock surveys.

The research done so far has shown some of the limitations of the individual-farm sample material and is pointing the way to the best methods of handling the returns. The data are being handled in three ways: (1) In making direct comparisons between the acreages or numbers of livestock reported currently for both present acreages or numbers and for the previous year; (2) in making comparisons of the ratios of acreages or numbers of livestock to total farm or crop acreage as reported currently with similar ratios of the previous year (large samples are used but they do not necessarily include identical farms for both years); and (3) in making direct comparisons between identical farms for the present and the previous year.

Because of the highly selective nature of the individual-farm returns, many problems of bias arise. The development of methods of measuring bias has involved much research.

The application of the theory of sampling to these three comparisons has thrown light on the question of how large a sample is needed in order to obtain a desired degree of precision in the results. The studies so far completed show very clearly that in the direct comparison of the acreage of a given crop for two years on the identical farm, a very much smaller sample will result in the same degree of precision as will a larger sample when the ratios of the acreage of a given crop to the total farm acreage from different farms are compared for the two years. Many other discoveries have been made which are being incorporated in the methods used in handling sample data both in Washington and in field offices.

A number of fundamental questions remain unanswered, such as the measure of the increase in the precision of the results when the crop correspondents are distributed by township over results obtained when the reports are obtained by random selection, and the effect of different degrees of stratification of the sample, etc. Work on these problems will be continued. In the field of measuring fundamental relationships between economic and other environmental factors and the change in acreage from year to year or in crop yields per acre, enough has already been done and the results have been sufficiently valuable to warrant immediate expansion of this type of research.

OUTLOOK STUDIES

Attention has been given to gathering additional data for use in preparing the bureau's Outlook Reports. Questionnaires have been distributed and the data obtained have been tabulated, analyzed, and used, in connection with information available in other divisions of the bureau, in the making of the report on the outlook for the major farm crops. One representative is giving a large part of his time to supplying information to organizations which are working toward the stabilization of the livestock industry.

Field studies were made covering the age and variety of pecan and peach trees. The field work was practically completed by July 1, and the questionnaires, many of which were gathered by farm-to-farm visits, are now being tabulated. Reports will be made in cooperation with other divisions of the bureau.

A special study was undertaken in the Hood River apple district in Oregon to determine the factors affecting the size of apples with a view to developing a method of forecasting in August of each year the sizes of the apples in the forthcoming crop. The study was brought to a successful conclusion by the end of the year, and the results will be used during the current year by the cooperative apple association in the valley in making their sales contracts.

FARM PRODUCTION AND INCOME

A great deal of time has been devoted to estimating by States the gross income of farmers. These studies have included estimates of the production, utilization, and value of meat animals, milk, poultry, eggs, and

honey, as well as of most of the crops grown. A large number of questionnaires concerning the utilization and disposition of farm crops were sent out, the results of which were used in estimating farm income.

COOPERATION WITH STATE AGENCIES

Cooperation with the State of Georgia was discontinued on October 1, 1928, and the work in that State is now conducted independently of any State agency. In all of the other 32 States where cooperative agreements are in effect, the relationships have been continued, and in some the scope of the work has been enlarged by increased State contributions. State cooperative agencies are now contributing total funds in excess of $200,000 a year to the crop-reporting work.

PRICE REPORTS

The price-reporting work, including the monthly reports on prices received by farmers for the more important products grown on the farm, and the quarterly reports on a large number of products bought by farmers, is being steadily improved through expansion of the list of reporters as well as by the development of better technic in the handling of the data.

During the coming year the division will have the task of furnishing to the Bureau of the Census county farm prices on most of the commodities to be covered by the agricultural census to be taken next spring. Work is already under way on this project, as many of the truck and fruit crops which will be included in next spring's schedule have already been marketed. Many of the prices on special crops grown in localized areas will be obtained by the State statisticians through field travel. The prices ascertained by the bureau will be used by the census office in ascertaining the values of the various crops produced in 1929 and the inventory values of livestock on farms on April 1, 1930. The prices will be weighted by monthly sales wherever possible in order to arrive at accurate values of each of the crops and livestock products like milk and eggs. Under an arrangement with the Census Bureau, sufficient technical and clerical assistance will be provided by that bureau to carry out this project.

MILK STATISTICS

Although milk and its products constitute a large and increasing proportion of the total food supply of the country and contribute nearly $2,000,000,000 per year to the gross income of farmers, there have never been adequate statistics on the production and use of milk in the various States. This has made it difficult for producers to analyze current trends correctly and to calculate future production and prices. It has also handicapped the department's workers in reaching sound conclusions regarding prospective changes in food production, agricultural efficiency, and returns. To provide a foundation for statistics on monthly and yearly milk production whenever facilities for such estimates might become available, the Division of Crop and Livestock Estimates has, for the past five years, collected reports from crop correspondents on the number of milk cows in their herds on the first day of each month, the number of these cows milked, and the quantity of milk produced. Recently some additional information has been collected regarding the age at which the heifers freshen, the disposition of the milk produced, and the butterfat test.

For each State preliminary calculations have been made of the number of milk cows of milking age, production of milk and butterfat per cow, number of calves to which whole milk was fed, and the quantity of whole milk thus utilized, the quantity of milk used for domestic consumption and butter production on the farms, and the quantity of milk sold from the farms. The calculations cover the years 1924 to 1928, inclusive. Present indications are that satisfactory statistical methods can be developed and that annual estimates of the milk production and consumption in each State can be made a part of the regular program of the division.

POULTRY STATISTICS

Poultry and poultry products make up an important item of farm production and, as is the case with milk, the available statistics relating to the production and use of these products are meager and unsatisfactory. During the last year an effort has been made to bring together all available information that might throw some light on the industry. As a result of this work, tentative estimates of the production of chickens and eggs by States have been made. For the last four years the division has carried two or three questions on poultry in the regular monthly schedules which have been helpful in ascertaining trends.

ENLARGED PROGRAM FOR TRUCK AND CANNING CROPS

During the World War, when emergency appropriations were made, the crop reports relating to fruit and truck crops were greatly expanded. At the close of the war these special funds were discontinued, and it was necessary greatly to reduce the scope of the reports. The major fruit crops more generally grown in the United States and a few of the fruit crops of a semitropical nature have been covered rather fully in the regular monthly reports of the bureau, but the reports covering most of the truck and canning crops had to be greatly reduced in scope.

Beginning with the fiscal year, July 1, 1929, an appropriation of $50,000 became available for expanding the fruit, truck, and canning crop reporting work. Considerable reorganization work was done toward the close of the last fiscal year in order to be in position to inaugurate a service on July 1 that would be satisfactory to the fruit, truck, and canning interests. In the development of this program the country has been divided into a number of districts with a fruit and truck crop statistician assigned to each district. For example, one statistician has been assigned to the Pacific Northwest, and another to the district comprising the States of Indiana, Ohio, and Michigan. The duties of these men are to keep in touch with the situation in their respective districts, especially with respect to the truck and canning crops, to make reports direct to Washington, and to assist the State statistician in collecting information for the monthly reports on the major fruits. Already a marked improvement has been made in the quality and scope of the reports, and they are meeting with the general approval of the interests most concerned.

DIVISION OF COTTON MARKETING

ARTHUR W. PALMER, *in charge*

The work of the Division of Cotton Marketing embraces service, regulatory, and research activities. It is carried on under authority of the following statutes: The United States cotton futures act, August 11, 1916, as amended; the United States cotton standards act of March 4, 1923; the act of March 3, 1927, authorizing the Secretary of Agriculture to collect and publish statistics of the grade and staple length of cotton; and the act of April 12, 1928, relating to investigation of new uses of cotton.

ENFORCEMENT OF UNITED STATES COTTON FUTURES ACT AND UNITED STATES COTTON STANDARDS ACT

In the general enforcement work a number of amendments to regulations under both the cotton futures act and the cotton standards act have been prepared, and a revised edition of the regulations under the last-mentioned statute has been published.

MILLIMETER DESCRIPTIONS

In June, 1928, the solicitor gave out an opinion in which he held that under present usage millimeter description as applied to cotton which is of, or within, the lengths embraced in the official staple standards is contrary to the cotton standards act. As soon as the new requirements became generally known and understood the official cotton standards of the United States for length of staple became the basis of the interstate and export trade in cotton, and the leading cotton exchanges of Europe, with the exception of Liverpool, which now has this under advisement, provided facilities for arbitration based upon the official staple types. The disposition of the trade in the United States to comply with the requirements has been apparent, and the investigation of the few complaints of continued sale on millimeter descriptions disclosed no willful violation in any case. Another important development has been the cooperative arrangement effected between the American shippers and various of the European organizations for representation on appeal arbitration committees abroad, a plan which has functioned very satisfactorily to buyers and sellers alike.

SOUTHERN DELIVERY ON FUTURES CONTRACTS OF THE NEW YORK COTTON EXCHANGE

On November 16, 1928, the New York Cotton Exchange amended its by-laws so as to provide that cotton tendered in settlement of its contracts under section 5 of the United States cotton futures act shall be "deliverable from licensed warehouses in the ports of New York, Norfolk, Charleston, Galveston, Houston, or New Orleans * * *." Trading in the new form of contract, which thus made provision for delivery at southern ports, began on January 2, 1929, and the first delivery month under the new contracts is October, 1929. This will necessitate the establishment of boards of cotton examiners at Charleston and Norfolk.

UNIVERSAL COTTON STANDARDS CONFERENCE

The third Biennial Universal Standards Conference provided for in the agreements between the United States Department of Agriculture and the nine leading cotton exchanges and associations of Europe was held in Washington in March, 1929, for the purpose of approving copies of the universal standards for American cotton for use by the department and by the European organizations. Sixty-five full sets of copies of the universal standards—a total of 1,300 boxes—were approved.

Consideration was given to the question of including standards for spotted and tinged cotton and for long-staple cotton under the universal-standards agreements, but no definite agreement was reached.

PREPARATION AND DISTRIBUTION OF OFFICIAL COTTON STANDARDS

The Universal Cotton Standards Conference and the revision of various standards placed an unusually heavy burden upon the division, but all this work was handled with very satisfactory results. During the year 3,892 boxes of the standards for grade and color and 17,195 staple types were distributed, as compared with 4,625 boxes and 10,762 staple types during the fiscal year 1928. The sum of $28,917.25 was collected from these sales of practical forms and $23,955.30 from sales of loose and rejected cotton. A total of 368 bales of cotton was purchased for the preparation of the practical forms at a cost of $46,396.04.

Orders promulgating revised standards for American Egyptian cotton and for extra white cotton were signed by the Secretary on April 10, 1929, to become effective August 1, 1930. These standards were presented in tentative form to representatives of organizations of farmers, merchants, and others who were in attendance at the Universal Standards Conference of 1929, and these representatives unanimously approved the revisions.

CLASSIFICATION OF COTTON

The cotton futures act provides that all cotton intended for delivery on future contracts shall be classified by officers of the department. Boards of cotton examiners are maintained in New York, New Orleans, Houston, and Galveston and an appeal board in Washington. Plans are under way to provide for boards of examiners in Norfolk and Charleston to meet the requirements of southern delivery on future contracts on the New York Cotton Exchange.

There was a marked increase during the year in the demand upon the various boards for classification service. The number of bales classified was 446,181 (not including reviews), as against 137,695 during the fiscal year 1928. Collections during the year amounted to $200,724.61 and disbursements to $167,428.55. Of the total collections, $8,469.58 was for sale of loose cotton and the balance for classification fees. A balance of $152,550.96 was in the Treasury on July 1, 1929, for conducting the work of this project for the fiscal year 1930.

The cotton standards act makes available the classification services of the various boards of cotton examiners to all persons requesting such service at a cost of 40 cents for the determination of the grade and staple length, and character if desired, for each sample submitted. Classification as to any single factor of quality may be had for 20 cents per sample. In all, 35,946 bales were classed under this act.

DEMONSTRATIONS OF STANDARDS AND COTTON CLASSING

For a period of three months demonstration work in the classification of cotton according to the official standards was carried on at Columbia, S. C. Farmers and others were invited to submit samples for informal classification and were furnished, without charge, a memorandum showing the grade and staple length of each sample. This work attracted much interest and favorable comment, and almost 5,000 samples were submitted for classification.

The bureau has cooperated in conducting six schools at which qualified cotton specialists demonstrated the universal grade standards and the standard forms for official staple lengths. The demonstration of the universal cotton standards for grade and the official staple forms for staple length in European markets has been continued with very satisfactory results. The bureau's representative has been very helpful in obtaining the cooperation of European merchants in the effort to have American cotton sold throughout the world on the present staple forms expressed in inches instead of on a millimeter description.

Arrangements have been made for the foreign representative to demonstrate the universal grade standards and the official forms for staple length at the Exposition of Modern Trade to be held during August and September in Brno, Czechoslovakia.

SPOT COTTON MARKET SUPERVISION AND COTTON MARKET NEWS AND QUOTATION SERVICE

The lines of work embraced under this heading are (1) the supervision of the quotation of commercial differences by the spot-cotton markets which have been officially designated as such for the purposes of the United States cotton futures act, and (2) the cotton market news and quotation service.

Effective in March, 1929, the rules of the New York Cotton Exchange were amended to provide for future contract deliveries of cotton fifteen-sixteenths and 1 inch in length of staple at premiums above cottons of seven-eighths inch, the minimum length tenderable under the law. Premiums for these lengths are provided for by the New Orleans Cotton Exchange and the Chicago Board of Trade. Particular attention has, therefore, been given to the quotation of staple premiums in those designated spot markets wherein such premiums are regularly quoted. Continued close supervision has been maintained over the quotation of commercial differences applicable to various tenderable grades, and the 10 designated spot markets have been regularly visited and canvassed each month. A high degree of accuracy in these quotations has been maintained throughout the year, and practically no complaints from either deliverers or receivers on future contracts have been received.

The market news service has given particular attention to the interrelationships among the cotton markets of the world, and the world market conditions have been comprehensively visualized. Telegraphic reports were received frequently each week from many domestic cotton centers and weekly cable reports from cotton centers in England, Germany, France, and Italy. These reports contained up-to-the-hour information on the state of the demand for various grades and staples of cotton; qualities in supply and qualities sought; basis prices, grade differences and staple premiums, fixations, and other factors of cotton marketing information. The data thus assembled in Washington were carefully reviewed; then the more vital features were consolidated into a weekly review, which was telegraphed (by leased wire where available) each week to field offices for wide dissemination. In addition, there was prepared at branch offices a premium staple report which covered the prevailing premiums for cottons above seven-eighths inch, including lengths from fifteen-sixteenths up to $1\frac{5}{16}$ inches. Newspapers and periodicals were especially active in publishing the information assembled, and in this way the service was made available to a very large number who would not have been otherwise reached. It is estimated that the circulation of newspapers and periodicals that carried the various cotton market news service reports was about 4,500,000.

COTTON LINTERS

The number of requests for the classification of samples of linters by the board of cotton linters examiners increased greatly. Service and Regulatory Announcements, No. 115, was issued October 1, 1928, covering the standard grades for American cotton linters, the classification of samples and bales, and the licensing of classers. Tests have been made of the mattress-felting qualities of grades Nos. 1, 2, and 3 of each of the standard characters, southeastern, valley, and western linters. These tests have demonstrated that the breaking and splitting strength and the resiliency of mattress felts made of linters are directly correlated with the grade and character of the linters. Further work is being done on other grades.

GRADE AND STAPLE ESTIMATES (CROP AND CARRY-OVER)

In compliance with an act of Congress, approved March 3, 1927, a report was made on the grade, staple, and tenderability of cotton carried over on August 1, 1928. Similar reports for the 1928 crop were made each month and a final report on April 19, 1929, for the total 1928 crop as reported by the Bureau of the Census.

The data on which the carry-over estimate was based were obtained by classing a representative portion of the cotton carried over in consuming establishments, public storage and compresses, and on the farms. Estimates of the crop were based on the classification of cotton furnished by gins so

selected as to represent approximately 10 per cent of the cotton ginned in the United States.

In addition, reports were issued for each individual State in the Cotton Belt, as of October 26, 1928, January 4, 1929, and April 19, 1929. A separate report was prepared and forwarded, with a letter digesting such report, to each cooperating ginner, based on the samples received from his gin.

For the first time in history, adequate means were provided in 1928 to make and publish figures on the quality of cotton which took account of the grade and staple of the cotton carried over on July 31, 1928, and for the crop produced in the Cotton Belt.

CARRY-OVER

The Bureau of the Census reported 2,531,000 bales of cotton on hand in continental United States at the end of the year July 31, 1928. Of this amount a little over 95 per cent, or 2,415,000 bales was American upland cotton. Of the American upland cotton, all but 221,000 bales were tenderable under section 5 contracts.

Over 27 per cent of the American upland cotton in the carry-over was 1 and $1\frac{1}{32}$ inches in staple length. The next most abundant staple length was seven-eighths of an inch. The carry-over did not show any overabundance of short-staple, untenderable cotton, there being only 88,000 bales of upland cotton shorter than seven-eighths of an inch.

There were 65,000 bales of Egyptian as against 45,000 bales of all other foreign cotton. Less than 1,500 bales of the Egyptian cotton were shorter than $1\frac{1}{8}$ inches in staple length. Of the other foreign cottons, all but 300 bales were either $1\frac{1}{8}$ inches or longer, or thirteen-sixteenths inch or shorter. This showed that there was practically no carry-over of foreign cotton seven-eighths to $1\frac{1}{8}$ inches, the lengths produced in greatest abundance in the United States.

CROP

Of the 14,269,000 bales in the crop of 1928 as reported by the Bureau of the Census on March 20, 1929, a little over 2,500,000 were untenderable on future contracts, a little over 2,000,000 of these because the staple length was shorter than seven-eighths of an inch. There were 5,947,000 bales only seven-eighths of an inch in staple length. This, together with the $\frac{13}{16}$-inch cotton, shows that over 56 per cent of the cotton produced in the United States in that year was seven-eighths inch or shorter in staple length.

In round numbers, 11,970,000 bales of American cotton, or 84 per cent of the 1928 cotton crop, were white, and 6,607,000 bales, or 46 per cent, were of white color and better than middling in grade. The grade produced in greatest abundance was strict middling white, of which there were almost 5,000,000 bales.

There is a very large demand on the part of experiment station directors and the agricultural press for more detailed information. A manuscript for a statistical bulletin embodying all of the above-mentioned facts and showing the staple length in the various States according to soil areas has been prepared. In cooperation with this bureau, the director of the State experiment station of Georgia has prepared a manuscript giving a detailed report of the quality of the cotton produced in Georgia, and the bureau has been advised that other agricultural experiment stations are preparing similar digests.

RESEARCH IN COTTON MARKETING

FIBER STUDIES

Research in connection with the cotton standards has been conducted from three different angles; namely, fiber, ginning, and spinning, with the primary objective of correlating the spinning behavior of the fibers and the properties of the finished product—yarns and fabrics—with the properties and characteristics of the fibers themselves. Scientific studies are being made of the influence of temperature and humidity on cotton classing and the measurable fiber properties.

Research is being conducted on such properties as strength, stretch, elasticity, drag, flexure, and fatigue of fibers representing different grades, staples, and characters. The tests are made of fibers in the different processes of manufacture, beginning with the raw stock and ending with the finished product.

One of the most marked developments has been made in the measurement of uniformity of fiber lengths, the technic of sorting having been perfected to a high degree. Effort is being made to define staple length scientifically and to develop a mathematical basis for the official staple types with a view of eliminating confusion and overlapping and of giving a stable basis for the different types.

The relationship between weight and length for fibers of different lengths is being critically studied. The results from a few samples indicate that weight is not a function of length, and a definite understanding of this relationship or variation in relationship is very important, inasmuch as a number of mathematical computations and technological considerations are vitally concerned.

A study of color and its relation to cotton standardization is being conducted, and considerable work has been done in developing and calibrating new equipment for the measurement of color. Color measurements have been made on material of different grades, staples, and characters at each stage in the process of manufacture. The results indicate that the presence of foreign matter in the ginned lint is an important factor influencing color and that, in the absence of foreign matter, there may be as much color difference between samples of a single grade as there is between samples of different grades. Other grade factors, including the amount and type of foreign matter and ginning preparation, are being studied.

GINNING STUDIES

Research in regard to the effect of gin machinery, organization, and operation on the physical properties of American cotton has been conducted on cotton of different staple, grade, and character. The effects of different cleaning equipment and of the moisture content of the seed cotton at the time of ginning are also being investigated. The disturbance of the uniformity of fiber lengths by ginning, that is, the decrease in percentages of the longer lengths and the increase in percentages of the shorter lengths, is being used as an index of ginning efficiency.

SPINNING STUDIES

Cottons of different grades, staples, and characters have been spun into yarns of different counts and twists. The various forms and amounts of visible waste are being determined. Certain especially selected stocks have been woven into fabrics of different specifications and the final products have been bleached, mercerized, and dyed. Data obtained by the usual methods of yarn and fabric analysis are being accumulated and the remaining manufactured products will be the subject of research. The ginned lint obtained from different conditions of experimental ginning are being similarly spun in an effort to translate the index of ginning efficiency, as obtained in the fiber laboratory, into terms of spinning behavior and yarn properties. Special studies are being made of such factors as roll settings, weights of rolls, drafts, and twists.

COTTON-MARKETING METHODS AND PRACTICES

Although it has not been possible to develop the project of cotton-marketing methods and practices, a certain amount of work has been done when acute situations arose which demanded information relative to arbitration, allowances, baling, compressing, taring, and patching practices, rules of organized markets and trade groups, and other matters.

United States Department of Agriculture Circular No. 47, entitled "Standardized Cotton Tare in Egypt," has been issued. This circular was very timely in view of the interest in net-weight trading and the use of a lightweight covering for American cotton. Information is being compiled regarding some of the costs of handling cotton in American and European markets. Investigations have also been carried on relative to baling, taring, and patching practices.

SOUTHWESTERN QUALITY PROBLEM

In response to the demand that the Department of Agriculture investigate the difficulties producers are having in some instances of marketing advantageously cotton grown under irrigated conditions, a study of the subject was undertaken.

The plan of procedure has been to trace individual bales of cotton grown under various observed local conditions as encountered by the growers in the irrigated sections of the Southwest, through the usual channels of trade, to the mills where they are consumed. Data are being collected on the behavior of the cotton and quality of the product. These data will be analyzed and correlated with growth data as a basis for recommendations for research in more specific problems of production and marketing.

COTTON-PRICE STUDIES

As a basis for determining the extent to which the price paid to growers for cotton on the primary markets varies

with the quality of the cotton and the extent to which the price paid to growers for cotton on the primary markets varies with the prices of cotton in central markets and with futures, price data for approximately 170,000 individual bales of cotton in 157 markets have been collected and are being studied. Collection of these data has been made in cooperation with the agricultural experiment stations in North Carolina, South Carolina, Georgia, Florida, Tennessee, Alabama, Mississippi, Louisiana, Arkansas, Oklahoma, Texas, Arizona, New Mexico, and California.

UTILIZATION OF AMERICAN RAW COTTON

Work on utilization of cotton is a part of a correlated program of research in which the Cotton-Textile Institute (Inc.) and the United States Departments of Commerce and Agriculture are cooperating.

The new uses committee, composed of representatives of the three organizations, sponsored an exhibit at the National Cotton Show which was held in Memphis, Tenn., in October, 1928. This exhibit was shown in connection with the cotton exhibit of the United States Department of Agriculture and met with great success.

COTTON DEMANDS, TRENDS, CHANGES, AND CAUSES

Basic data have been assembled for a study by countries of the trends and mill consumption of cotton of various growths. Data have also been assembled on the production, consumption, price, export, and import by countries, etc., of the various fibers competing with cotton. These, together with supplementary data, will be used in a study of the competition and trend in world consumption of cotton and other fibers.

ADAPTATION OF COTTON TO NEW AND EXTENDED USES

Studies of cotton bags and other containers in the wholesale grocery trade, and cotton bags in the fertilizer industry, were completed. Mimeographed reports based on both of these studies have been widely circulated. The study of cotton bags in the fertilizer industry shows that only a small percentage of fertilizer is now handled in cotton bags as cotton bags now cost more than burlap bags. Fertilizer dealers advise, however, that they use cotton bags when possible because it makes an attractive package, gives a better visibility for marking, and has a higher reuse value.

Study of the cotton bags and other containers in the wholesale grocery trade was made in cooperation with the Wholesale Grocery Association and the National Wholesale Grocery Association of the United States. This study indicated that more than a quarter of a million bales of raw cotton and cotton waste go into the manufacture of cotton bags in the United States each year. Most of these bags are used in the wholesale grocery trade, which consumes over 200,000 bales of cotton each year. This study revealed a large potential field for cotton bags where jute bags or bagging are now used, and indicated that the wholesale grocery trade might use more than 600,000 bales of raw cotton and waste each year. Spinning tests made on the garnetted cotton bagging showed that the cotton could be reused, but that it had lost approximately 40 per cent of its original strength. A study of the use of cotton bags and of other ways in which cotton is now being utilized in the power laundries of the United States, is being conducted. Plans have been made to survey the cotton States with respect to the use of the cotton picking bag and cotton picking sheet in an effort to discover the possibilities for increasing the use of cotton through these two uses.

GRADE AND STAPLE ESTIMATES (CONSUMPTION)

An estimate of the grade and staple of cotton consumed in the mills of the United States during the year ended July 31, 1928, was made, which covered 14,200,000 active consuming spindles out of the approximately 33,500,000 such spindles. A mimeographed report entitled "Quality of Cotton Spun in the United States" was issued.

The primary objective has been to show the domestic consumption of cotton by grade and staple length, since the American mills furnish the American grower his largest market. The domestic mills consumed approximately 6,000,000 bales during the year ended July 31, 1928, of which 6,500,000 bales were of American growth. More than 90 per cent of the American cotton was white in color, and 72 per cent of it was Middling or better in grade. The staple lengths consumed most extensively ranged from seven-eighths inch to $1\frac{1}{32}$ inches in length, of which

70 per cent was fifteen-sixteenths inch or longer. Most of the cotton imported into the United States during 1928 was 1⅛ inches or longer in staple.

In the manufacturing of four important products—rubber, pyroxylin-coated fabrics, oilcloth, and mercerized yarn—the quantites of cotton used have been maintained or increased during the past few years. The cotton consumed by these industries is of good quality.

COTTONSEED STUDIES

A plan has been devised for grading cottonseed on the basis of the relative quantity of the chief products obtainable as determined by chemical analysis. A committee made up of representatives of the Bureau of Chemistry and Soils and of this bureau has given careful study to the cottonseed situation and has made recommendations for the more accurate methods of sampling and analyzing samples.

DIVISION OF FRUITS AND VEGETABLES

WELLS A. SHERMAN, *in charge*

MARKET NEWS SERVICE

Steady growth, both in extent and usefulness, marked the year's work under the market news service. The leased-wire telegraph service continued to be the means for rapid dissemination of market news, including shipment reports, arrival and price information, and statements regarding local conditions in producing sections and terminal markets. Sacramento, Calif., was added to the western leased-wire circuit, and the wire was extended from Atlanta, Ga., to Montgomery, Ala. Plans were completed for a material expansion of the service during the fiscal year 1930.

Every available form of publicity has been used to carry to producers and others the information gathered and forwarded over the telegraph wires. Daily mimeographed reports continue to form the "backbone" of the service, although the broadcasting of reports by radio and the use of the press as a means of disseminating market information have been extended and intensified. There is a great demand for the mimeographed reports as a basis for the settlement of railroad claims, many thousands being furnished for this purpose alone. Numerous shippers and dealers maintain complete files of the daily reports for future reference. Approximately 15,327,000 mimeographed market reports were issued from the 18 market stations and the 40 temporary field stations of the division. This was an increase of 1,759,000 reports over the preceding year, although the mailing lists were revised frequently to remove the names of all persons who no longer desired the service.

Daily shipment information was reported by the carriers and published by this bureau on 35 of the most important fruits and vegetables, and complete market reports were issued in season on 22 of these. In addition regular news services were conducted on peanuts and on honey and beeswax, and special local reports were made on a large number of products during the heavy shipping season.

CARLOAD SHIPMENT INFORMATION

The volume of carload shipments reported by the carriers has gradually increased. The total of 1,088,095 cars of 38 products represents a net total increase of 44,149 cars over the number the previous year. Shipments of tree fruits especially were greater in 1928. As the car-lot movement has increased, there has been a demand for more extensive market news service. Daily telegraphic reports are received at Washington from several hundred transportation lines. These reports show the number of cars originating in each division superintendent's territory. Sixty-four of these reports are known as "consolidated wires," each covering an important railroad system or major part of such a system. Approximately 400 individual reports are received, chiefly from smaller transportation lines. In addition, 15,000 freight and express agents send monthly reports by mail, covering a greater number of products, which amplify and also serve as a check upon the daily telegraphic information. The shipment data have become more complete and accurate each year and are of greater value to the news service. Arrangements have been made in a number of cases to have daily telegrams showing car-lot destinations of certain products sent by carriers direct to temporary field stations.

UNLOAD REPORTS FROM PRINCIPAL MARKETS

Reports of unloads of 19 of the most important fruits and vegetables are received from 66 markets. In 27 of these cities representatives of this bureau obtain the information daily from rail-

roads, express companies and important boat lines. Truck receipts are included whenever it is possible to obtain this information. Railroad agents furnish the reports from 39 cities in which no bureau representatives are located. There is constant demand upon this bureau from growers, shippers, members of the trade, and others, for the unload data. In addition to meeting specific requests, press releases and mimeographed statements are prepared and distributed. The unload data are valuable as a basis for study of the supply and distribution of fruits and vegetables.

COOPERATION WITH STATES

The expense of operating field stations in producing sections continued to be shared by growers and shippers as well as by State agencies. Without this aid, the service would, of necessity, be greatly curtailed. Several States assisted actively in distributing market reports, resulting in a wider dissemination of the information. In a few cases, special cooperative services were conducted on particular crops. For example, a market news program on grapes was rendered in New York and Pennsylvania, the State office at Buffalo issuing the reports on the crop.

REVIEWS, SUMMARIES, AND SPECIAL REPORTS

In the Washington office, current tabulations are maintained of current prices at all the leading markets and shipping points. Special reviews and summaries of market conditions are prepared, as well as articles for trade papers and farm journals. A great deal of information is furnished in answer to special requests. The data are used as the basis for comprehensive statistical bulletins and economic reviews.

A large number of weekly and monthly reviews, which make available in condensed form the data gathered, are prepared and distributed to special mailing lists. These reviews furnish a basis for comparison with previous years. Further work has been done in preparing special weekly and monthly reviews for particular papers, mainly farm journals, in different sections of the country. Some of these outline market conditions and the probable future trends. Effective cooperation has been given the bureau by the Associated Press and by newspapers generally throughout the country. Special attention has been given to the preparation of market data in the form desired by the press and to the furnishing of the type of information of greatest usefulness to each class of subscribers and to the different sections of the country.

At the close of each temporary field station a summary of the information which was published daily and a general review of the market season for the products of that territory was prepared for the special benefit of those on the local mailing list. This summary points out the successes and failures of the past season and serves as a guide in planting, harvesting, and marketing during the following season. Approximately 50,000 copies of 65 different summaries were issued.

INSPECTION SERVICE ON FRUITS AND VEGETABLES

All previous records were broken for the number of inspections of fruits and vegetables, both at shipping points and receiving points. At shipping points there was an increase of 18,367 cars and at receiving points 5,202 cars, with a total of 266,831 inspections, as compared with 243,262 for last year.

RECEIVING-POINT INSPECTIONS

A total of 37,632 commercial inspections were made at 40 important receiving markets and adjacent points. In addition, large quantities of products were inspected for the United States Navy, the Marine Corps, and other governmental agencies.

Greater demands have been made for service by handlers and receivers of large quantities of fruits and vegetables, such as cold-storage companies and express companies. In some cases special contracts are entered into at a reduced rate when a large number of cars are guaranteed and conditions are favorable for rapid inspection. Some companies furnish labor for opening and closing packages. This expedites the work and reduces the cost to this bureau. The work for large terminal organizations is growing rapidly.

EXPORT STANDARDS FOR APPLES

The export standards for apples promulgated in October, 1928, have been of great assistance to foreign buyers. Official certificates are issued on request for certification for export bearing the statement, "Lot meets U. S. standards for export." These certifi-

cates assure the buyer that the apples were tightly packed, that not more than 5 per cent were off condition, and that the apples were not further advanced in maturity than firm ripe. The adoption of these standards has eliminated much misunderstanding between buyers and sellers and provided a satisfactory basis of trading. A total of 2,340 cars was inspected on the basis of the export standards in New York alone.

AUCTION INSPECTION

The agreement entered into with the United States Fruit Auction Co., of Chicago, providing for inspection of juice grapes sold at auction, was renewed at the beginning of the 1928 season, and 1,216 cars were inspected. This work has increased every year since it was started, and buyers, as well as the auction company, have expressed their appreciation of the valuable service rendered by the Federal inspectors.

SHIPPING-POINT INSPECTION

A total of 229,199 cars was inspected at shipping points. Only 190 reinspections were called for at terminal markets, 50 of which sustained the original inspection. Washington showed the greatest increase of any State, the number of inspections being 37,505, as compared to 29,497 for the previous year. Nearly all shipping-point inspections were made under cooperative agreements with various States. In Louisiana and South Carolina the agreements provide that the joint employee may devote such time as is not required for supervision of inspection work to extension work on standardization or marketing. These arrangements have proved highly satisfactory as a means of rendering service to growers.

INSPECTION OF CANNERY TOMATOES

Inspection of cannery tomatoes when delivered to the factories has been a recent development. During the past year 10,097 growers' loads were inspected in Indiana and New York, and experimental work was carried on in Delaware in cooperation with the State bureau of markets. The prospects are that the work will be greatly increased this season in Indiana, New York, and Pennsylvania, and experimental work will be carried on in a number of other States. Both the growers and the buyers who have tried the system are heartily in favor of trading on the basis of the special United States grades recommended for canning stock.

RESEARCH AND STANDARDIZATION

Standards have been prepared to date for 44 of the principal fruits and vegetables. Since two or more sets of standards are necessary for different types of the same commodity if it varies widely, 57 United States standards have been issued. A number of the standards were revised during the year, and new sets were issued for 6 additional products. Much interest has been shown and many requests have been received for the establishment of additional standards. The trade is particularly desirous of having grades established for various canning crops.

The success and popularity of the market inspection and market news services has been tremendously increased by the preparation of standards which have met the needs of the trade. These services have been closely coordinated with the research work on methods of packing, grading, handling, and marketing these products.

In addition to the statistical publications containing detailed information on production and distribution of fruits and vegetables, bulletins have been prepared covering the marketing of a number of crops. A Farmers' Bulletin on marketing late-crop potatoes contains up-to-date information on conditions and practices in the important commercial producing areas and markets. The relation of supply to average seasonal price, which is of vital importance in successful marketing, is treated and illustrated graphically.

Increased interest has been shown in recent years by growers and shippers in economic studies of production and marketing of various fruit and vegetable crops. Information on the probable trend in production, costs of production, trade channels and methods, consumers' demand and preferences, distribution, grading, competition, prices, and other phases of marketing have been requested for many crops. A number of the divisions of this bureau cooperate in this type of work.

An economic study of the apple industry has been completed recently. A feature of this study was an analysis of the apple receipts by varieties and States of origin in 41 cities which receive two-fifths of the carload ship-

ments of apples of the United States. The information on varietal composition of market supplies, obtained from records and estimates of dealers, has never been available heretofore and should prove of value to the apple industry. Detailed information was also made available on auction and jobbing prices, containers, trade and consumer preferences and practices, local receipts, redistribution of carload receipts, and other matters of interest. A similar study covering the pecan industry is being conducted. An economic study of the eastern grape situation is being made in cooperation with the New York State College of Agriculture, and of the canning-peach industry in cooperation with the State of California. At the request of the prune growers' associations, a study is being made of the fresh-prune industry of the Northwest.

The motor truck has become an important factor in the commercial movement of fruits and vegetables. Figures on car-lot shipments and receipts are in many cases inadequate for market news and statistical purposes on account of the large quantities transported by motor truck. To obtain definite information on this movement, a study was undertaken in cooperation with the State of New Jersey and the New York Food Marketing Research Council. Arrangements were made a year ago with 100 dealers on the New York jobbing markets to report by telephone to our market news office their motor-truck receipts of each fruit and vegetable by States of origin. This information is published daily as a part of the market news service. Successful operation of this service has led to the establishment of similar services in a number of other cities. A study is being made of the distribution of motor-truck shipments and the conditions under which the motor truck is used and its effect upon marketing fruits and vegetables.

The bureau's fruit and vegetable foreign marketing specialist stationed in London continued to furnish valuable information to exporters with respect to European conditions and prices. A biweekly circular was issued in London and forwarded to European agents who distributed American fruits, containing information on grades, inspection, movement, and prices in the United States. The foreign marketing specialist spent several months in the United States attending meetings of growers and shippers, discussing fruit-export problems, and furnishing information on European markets to those interested.

STANDARD CONTAINER ACTS

The passage of the standard hamper and basket act of 1928 greatly increased the standard-container work. In addition to the grape baskets and berry boxes which were included under the act of 1916, hampers, round-stave baskets, and splint baskets are now under the jurisdiction of the department.

These acts are administered as a service project; only one prosecution has ever been found to be necessary. A large volume of work is necessary in making tests and measurements of the samples of containers submitted in order to pass upon their legality. A much larger percentage of the samples of the large containers covered by the act of 1928 have been found to be nonstandard than has been the case with the smaller containers covered by the act of 1916. More conferences with manufacturers have been necessary, and more educational work has been done. Very satisfactory progress has been made, however, and excellent cooperation has been given the bureau.

PRODUCE AGENCY ACT

There has been a great increase in the number of cases which seem of sufficient importance to justify personal investigation, and complaints have been received which involve serious abuses. Although a number of complaints have related to minor matters, shippers in general have realized that cases should be submitted to the department only when they believe actual violations of the act have taken place. Of the 229 complaints received, 134 were personally investigated. In 43 cases upon which reports have been made as to the amount due in settlement, a total of $4,608.20 has been paid to the complainants. Payments have been made in other cases, but complete returns have not been made to this bureau. To date, only 1 case has been brought to trial. In this case the defendant pleaded guilty and was fined $100. A number of cases were before the Department of Justice at the close of the year.

The work of the year has demonstrated that many real abuses exist in the fruit and vegetable industry and that a great deal of work remains to be done looking toward their correction. Fine cooperation has been given to the bureau by the majority of the trade.

DIVISION OF LIVESTOCK, MEATS, AND WOOL

C. V. WHALIN, *in charge*

GRADE STANDARDIZATION

LIVESTOCK AND MEATS

The tentative standards used as the basis for the market news service were continued and their use carefully scrutinized. Most of the investigational work centered on hogs and lambs, special attention being given to the former.

Partly as a result of the natural increase in interest in livestock standardization and partly through the needs which have developed in connection with the direct marketing of hogs on a large scale, an active demand for standards for hogs on the part of both producers and packers has developed. Several meetings with representatives of livestock shippers and the Institute of American Meat Packers were held and standards for a set of six grades for slaughter barrows and gilts were formulated and submitted to the industry for criticisms and suggestions.

Tentative standards for grades of lamb were worked out. Side-view and top-view photographs of the different grades of lambs, live and dressed, were taken, and measurements were made of approximately 550 lamb carcasses to determine the relative dimensions of animals representing the different grades and to establish the relationship of physical factors to grade.

A correlation study of the grades of live lambs and their carcasses was made to determine the grade of the dressed product obtained from lambs usually graded as culls or throw outs by packer buyers. Small lots of these cull lambs were graded and photographed alive, and later graded as carcasses. A large number of the live lambs that were sorted out as culls by the buyers yielded carcasses that were graded from one to two grades higher by both the department's grading committee and the packer's grading expert.

Service and regulatory announcements were published, covering official standards for slaughter cattle, vealers, and slaughter calves, and for veal and calf carcasses. A publication outlining the advantages of standards for livestock and meats was issued. Manuscripts have been drafted covering market classes and grades of yearling beef, market classes and grades of pork carcasses and fresh-pork cuts, and grades and the retail cuts of beef. Colored posters illustrating standards for steers, cows, and heifers were completed.

WOOL

Increased interest has been manifested in the subject of wool standards both in this country and abroad. At a meeting of the International Wool Conference held in Paris in November, 1928, the French delegation recommended that the United States standards be made the basis for all negotiations. The matter was placed in the hands of a committee for study and report at the next meeting of the conference in 1929. In the tariff bill pending in Congress the standards are made the authority for the determination of the grade of wools imported into the United States and dutiable under the act.

For the purpose of investigating the factors which affect the shrinkage of wool, the division has carried on an extensive program in wool-scouring research. Hundreds of samples of wool have been tested in the laboratory under semicommercial conditions. For the third consecutive year tests have been made on wools from several flocks in selected localities, and interesting data have been obtained. When completed the results of the investigations should provide a scientific basis for the estimation of the shrinkage and yield of United States wools and should be of great assistance to American wool growers.

The moisture question is extremely important in wool marketing, since wool shipped from an arid region to one of greater humidity gains considerable weight. Wool that has been scoured and dried on standing absorbs moisture also. An attempt is being made by this bureau to work out the relation between the grade of wool and the moisture content and "regain" and to devise satisfactory tests for measuring moisture content.

MOHAIR

The great expansion in the mohair-growing industry has made the need for standards for the grades of mohair more imperative. At meetings held with producers in a number of States the work was discussed. Important contacts were made with dealers and manufacturers in the New England States, where manufacturing activity

is centered, and the cooperation of a number of these interests was obtained.

Tentative grades for the preliminary classification of mohair for marketing have been formulated. Practical forms of these grades are in preparation for distribution among dealers, manufacturers, producers, and others, in order that the grades may be widely reviewed and given commercial application. Further investigational work will be done by members of the staff.

HIDES AND SKINS

Material progress was made in developing standardized grades for hides and skins. Approximately 3,700 copies of the tentative schedule of market classes and grades of hides and skins were mailed to tanners, brokers, dealers, and producers for suggestions and criticisms. Several conferences were held with groups of users of hides and skins, and with livestock slaughterers, whose annual production totals 15,000,000 hides and skins. Approximately 700 tests were conducted at tanneries to determine the correlation between the qualities of the raw hide and the qualities of the finished leather. The results obtained from these tests will be very helpful in developing standardized grades on a sound and practical basis.

QUALITY-OF-MEAT STUDY

A study of the factors which make quality and palatability in meat is being carried on in cooperation with the Bureau of Animal Industry, the Bureau of Home Economics, and the State agricultural experiment stations. In connection with this study during the past year 676 cattle, 110 hogs, and 750 lambs were graded. The data which have been collected up to the present time through the grading of more than 2,000 cattle have been placed on cards and when tabulated and analyzed are expected to show the changes in grade resulting from intensive feeding; the relative ability of graders to ascertain the carcass grade of an animal before slaughter; the effect of daily and total gain in weight on carcass grade; the effect of kind of feed, geographical location, and breed upon the carcass grade; and the causes of change in grade from beginning to end of feeding period with calves, yearlings, and mature cattle of both sexes.

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METHODS AND PRACTICES OF MARKETING

DIRECT BUYING OF HOGS

The work of compiling and analyzing data relating to the direct buying of hogs by packers was continued. Results to date indicate that the expansion of operations by interior packers (those located away from terminal markets), together with the decrease in the volume of receipts at the terminal markets, has stimulated a general move on the part of a number of terminal-market packers to supplement their central-market purchases with hogs bought direct in the country.

The tremendous growth of direct buying during recent years can, perhaps, be partially explained by improved transportation. The extensive highway-development programs of many States, together with increased use of the motor truck for livestock transportation, have tended to foster direct buying by enabling the interior packers to enlarge their territories and by insuring adequate supplies to operate their plants. The expansion of livestock truck transportation has been enormous, and, according to recent figures, the movement has not yet reached its peak.

The use of the radio and the standardization of market news has kept the livestock producer in close touch with the market and has given him information on which he could sell his hogs more intelligently than ever before; hence he is not averse to selling his stock direct if the opportunity offers.

SUPPLY, DISTRIBUTION, DEMAND, AND PRICE STUDIES

Analysis and interpretation of economic information obtained through the market news service and other sources continues to be a major research activity. Results of these studies are presented to the public in the form of the semiannual outlook reports on cattle, hogs, sheep, and in reviews, radio talks, and special reports dealing with various phases of the livestock situation. This information helps producers to make proper adjustments in their production and marketing programs, and enables distributors to effect more efficient and economical distribution of product. The Livestock Review for 1928 was published as Miscellaneous Publication 54, and 17 radio talks analyzing economic

conditions in the industry were broadcast over a chain of stations that serve the major portion of the country.

STATISTICAL SECTION

The market news service and other activities of the bureau furnish a volume of statistics which are compiled as permanent records to serve as a basis for research work and recommendation for improved production and marketing methods. Among these compilations are the following: Daily livestock prices by 60 classes and grades at 23 markets; daily fresh-meat prices by 43 classes and grades at 4 markets; daily cured-meat prices by 20 classes and grades at 4 markets; weekly wool prices at Boston; weekly, monthly, and yearly averages of prices; daily receipts of cattle, calves, hogs, sheep, horses, and mules at 18 markets; and classes of meat covered by meat-grading projects. In addition a very large number of reports and summaries are prepared regularly for various mailing lists of those desiring special information and for agricultural journals and newspapers.

PUREBRED LIVESTOCK PRICE SURVEY

The seventh purebred livestock sale-price survey, covering sales in 1928, was made, and the results were summarized in 19 separate reports. This survey indicated that the trend of purebred livestock prices during 1928 continued upward for beef and dairy cattle and for sheep, but that the prices of purebred hogs declined. Information of this kind, based on actual reports of breeders, tends to stabilize prices and informs buyers and sellers as to prevailing values. It should result in stimulating the demand for purebreds and thus tend to bring about an improvement in the general quality of all livestock produced.

QUARTERLY WOOL STOCK REPORT

Surveys were made of stocks of wool, tops, and noils in the hands of dealers in the United States. Approximately 300 dealers were circularized. These data were combined with reports on holdings of manufacturers, as obtained by the Bureau of the Census, and published in mimeographed form. The reports provide a basis for more intelligent action by producers, dealers, manufacturers, and various branches of the Government.

MARKET NEWS SERVICE ON LIVESTOCK, MEATS, AND WOOL

Branch offices were maintained in 24 cities throughout the year. The leased wire was extended to Sioux City, and the service was expanded so as to put it on a comparable basis with other large markets. Extension of the leased wire to Montgomery, Ala., made it possible to give wider dissemination to market information through the South. Plans were made for inaugurating a meat-reporting service in San Francisco and enlarging the meat-reporting service in New York City to include locally dressed meats.

A report of average wholesale prices of fresh and cured pork products is now made available monthly from Chicago and New York. In order to keep the public informed as to important changes in slaughter supplies of hogs, arrangements were made for releasing weekly figures of inspected hog slaughter at nine important market centers. To meet the situation brought about by the increase in direct marketing, arrangements were made for releasing and disseminating, early each morning, reports segregating receipts of hogs consigned direct to packers from those consigned for sale on the open market. To make the Boston Weekly Wool Market Review of greater value to the trade, the release date was advanced from Wednesday to Monday, thus making it possible to get the report to subscribers 48 hours earlier than previously.

Much attention was given to increasing the scope and value of the daily and weekly market reports prepared for radio release. Not only were the style and content of the reports improved, but greater attention was given to the utilization of broadcasting stations best qualified by power and equipment to render the most effective service. Approximately 100 broadcasting stations located in all sections of the country are now making use of the market news service without expense to the bureau.

At the request of the carpet-wool users, an information service on the crop prospects in the carpet-wool-producing countries was inaugurated. Information obtained by department representatives and members of the Consular Service, abroad and from other sources, is made available to the industry through mimeograph releases.

The World Wool Situation, a mimeographed report of 10 to 15 pages, covering many aspects of the wool sit-

uation in this and in foreign countries, was prepared and released each month.

Expansion in the dissemination of practically all types of reports released was marked, and a greater degree of accuracy and clarity was obtained. The cooperation given by the leading press associations was very gratifying. More livestock and wool market information than ever before was sent over the various telegraphic news circuits of the press associations. One leading association reports that some of this information was sent over each of its circuits daily during the year. An incomplete survey of newspapers utilizing press-association services revealed that approximately 700 press-association papers were using the reports. Trade and agricultural papers also made greater use of the reports, and livestock commission and stockyard companies utilized the service more generally than heretofore in connection with their market letters and advertising circulars. A total of 4,419,429 mimeographed market reports were released.

No reduction in the CND services of the commercial telegraph companies was apparent during the year despite the increasing use of radio as a prompt and dependable means of news dissemination.

EDUCATIONAL DEMONSTRATIONS AND SERVICE

One representative devoted a large part of his time to attending meetings of livestock producers, vocational agricultural students, and others interested in livestock marketing, at which he gave demonstrations in livestock grading and delivered addresses on consumer preferences, market requirements, and methods of adjusting production to demands to bring increased returns. He visted 11 States, attended 11 State or district livestock association meetings, and held about 75 demonstration or livestock-improvement meetings. Other representatives attended meetings of retail meat dealers, purchasing agents, vocational students, and livestock producers at which they delivered addresses on economic conditions in the livestock and meat industry. In addition, a number of demonstrations were made and exhibits shown explaining and demonstrating the classes and grades of livestock, meats, and wool at livestock shows and expositions.

MARKET-GRADING SERVICE

The meat-grading service was carried on in 15 cities. There was a marked increase in the quantities of meat graded at practically all points and particularly at the larger markets, such as Chicago, Kansas City, New York, and Boston. Approximately 23,500,000 pounds of meat (excluding beef graded and stamped) was graded; almost half of it was for Federal institutions and slightly more than half for commercial concerns.

BEEF GRADING AND STAMPING SERVICE

The beef grading and stamping service was continued at eight market centers. Four beef graders were employed full time on beef grading, and four other employees devoted part time to the work. A total of 58,571 carcasses, representing the equivalent of 31,712,000 pounds of beef was graded and stamped.

The interest in beef grading and stamping has increased materially since its inauguration. Meat retailers, hotel-supply houses, dining-car service of various railroads, and others use the service. Large chain-store organizations are constantly increasing the quantity of graded and stamped beef handled in their markets from week to week.

GRAIN DIVISION

H. J. Besley, *in charge*

ENFORCEMENT OF THE UNITED STATES GRAIN STANDARDS ACT

General field headquarters were maintained at Chicago, as well as the central board of review and the force in charge of inspection efficiency. Under direction of general field headquarters, Pacific coast headquarters were maintained at Portland, Oreg. There were 4 division supervisors and 35 district offices.

At the close of the year there were 162 inspection points in 35 States, and 479 licensed inspectors. Hearings were held in 8 cases involving violation of the grain standards act, and recommendation for the publication of findings were made in 6 of these. Investigations were made in other cases of irregularities, and adjustments were brought about. Attention of 70 shippers was called to the fact that grain of inferior quality was found in the bottom of the car, and that proper samples could not be obtained from such cars by ordinary methods.

ACTIVITIES UNDER FOOD AND DRUGS ACT

In addition to the enforcement of the United States grain standards act, this bureau cooperates in securing com-

pliance on the part of the grain trade with the provisions of the food and drugs act in so far as that law applies to whole grain. Under the food and drugs act, the bureau has undertaken to prevent the mixing of a product commonly termed "screenings," as well as the mixing or blending of distinctly low-quality grain with sound grain since practically all wheat and much other grain which meets the requirements for grade No. 2 is intended for human consumption.

The usual effort of many terminal elevators is to blend several qualities of grain together so that the resultant mixtures will barely come within the limits of the No. 2 and No. 3 grades of the official grain standards, which are the usual contract grades. Abuses of the mixing practice assumed such proportions that special attention was given to preventing adulteration of sound grain by addition of screenings and low-quality grain. More than 200 carload lots were formally objected to for mixing purposes, and information was requested as to their disposition. Cooperation was received from export elevators and from grain exchanges in preventing this practice.

SPECIAL GRADING PROBLEMS

The 1928 hard winter wheat crop was comparable with the crop of 1927; it was well matured and of good weight, but adverse weather conditions at harvest time, use of the combine, and poor or inadequate storage and handling conditions resulted in a considerable quantity of out-of-condition, musty, and heat-damaged wheat. The rancidity test developed in the grain division research laboratory to determine the facts relative to musty or out-of-condition grain has proved to be of immeasurable assistance to the board of review in its interpretation of musty and out-of-condition odors.

Because of heavy winter-killing, the soft red winter wheat crop was extremely short and presented no major grading problems. Conditions affecting the hard red winter and durum wheats were practically identical with conditions last year, but probably a little more of the crop fell in the lower grades on account of frosted and green wheat caused by early killing frosts in the northern part of the spring wheat belt. Pacific coast wheats graded high, with no outstanding grading problems.

The corn crop was one of the best in years, moisture and test weight being the principal grading factors.

The oats crop, as a whole, was below average in general appearance because of unseasonable weather at harvest time, so that little of the crop fell in the first two grades.

The barley crop in the Central States was affected with scab. Much of the barley from this section was graded sample grade on account of "distinctly low quality." This became a major grading problem in which the test for rancidity again proved useful.

The rye crop carried the heaviest infestation of ergot of that of any year since the Federal grain standards were established; consequently, ergot was an outstanding grading factor. Two of the larger terminal markets resorted to washing rye for the purpose of removing the ergot. Poor processing resulted in some rye grading sample grade, but as processing methods improved this trouble disappeared.

Complaints of the manner in which the standards have been interpreted have been mostly to the effect that the grades were too rigidly applied and that this application resulted in loss to producers and country shippers of grain. Normally, from 80 to 95 per cent of the production of any given crop is of a quality which admits it into one of the higher grades, and it has been the consistent view of the bureau that grain of good quality should be protected in commerce by the exclusion of low-quality grain from the higher numerical grades. The basic price of a commodity is lowered if an inferior product is admitted under a grade, brand name, or trade-mark that presumes to represent a commodity of higher quality.

INSPECTION EFFICIENCY

Marked improvements were brought about in the accuracy of the inspection work and in the uniformity of application of the Federal standards. Additional supervision has resulted in greater care on the part of the licensed inspectors in grading of shipments of grain from all markets, especially from points at which no supervision offices are located. The supervision work was supplemented by an active campaign to bring about a better understanding of the Federal standards on the part of country grain dealers for the purpose of improving inspection uniformity throughout the country.

Four multigraphed reports covering general information concerning stand-

ardization of grain, methods of handling and storing grain to maintain or improve its grade, and grain-inspection methods and procedure have been given wide distribution through publication in five grain-trade papers and in agricultural publications. In this way general instructions and information have been circulated to practically all grain dealers in the United States. There has been a demand for supplies of these reports from agricultural colleges conducting courses in grain grading and country-elevator management. Supplies of the reports and publications regarding grain inspection have been sent to 15 agricultural institutions for use in classroom instruction and grain-grading laboratories.

Close cooperation has been maintained with grain dealers' associations. They have assisted in the distribution of educational material and arranged sectional meetings at which grain-grading instructions were given. Grain-grading instructions have been given by supervisors at over 200 meetings of grain producers and growers at country points east of the Pacific coast division. It is the experience of the supervisors conducting the grain-grading demonstrations at country points that country dealers are anxious to learn how to apply the standards and that they realize the necessity for grading grain, especially their shipments to terminal markets, if they are to protect fully their own interests through calling appeals under the United States grain standards act. Country dealers are learning to grade grain purchased from growers, thus carrying the benefits of standardization to the growers through premiums paid for grain of superior quality.

A large quantity of grain was moved long distances on shipping-point inspection, for example, west-coast soft wheats moved to southeastern mills to meet the deficiency in soft red winter wheat; and high-protein hard wheats were shipped from the Southwest to the milling centers.

Progress was made in the tabulation and analysis of data showing why the different crops of grain have been of the grades assigned. This information shows the relative importance of such grading factors as damaged kernels, moisture, and mixtures of other wheats in the various crops, and in grain from the different sections of the country. Such information has been used extensively by crop-improvement associations and agronomists in planning field work, and has been used effectively in educational work in showing the necessity for grain grading at country points as a means of preventing losses in handling and mixing grain.

GROWTH OF APPEAL SERVICE

The year just closed again broke all previous records for the number of appeals handled by offices of Federal grain supervision. These appeals were called by interested parties from inspections performed by licensees and resulted in the issuance of Federal grade certificates on 84,135 lots of grain. The majority of these appeals involved single carloads of grain, but many of them covered large quantities of grain shipped in bulk by vessel and barge on the Great Lakes and Mississippi River as well as a few in the export trade. For example, 457 of those appeals handled by grain supervisors at the various inland ports and export markets covered a total of 28,000,000 bushels of different kinds of grain. In addition to the appeals taken directly to the local offices of Federal grain supervision, 1,725 board appeals were taken to the boards of review at Chicago, Ill., and Portland, Oreg.

Buyers and sellers of grain, including producer's representatives at certain of the larger terminal markets, continued to take advantage of this privilege afforded them by the terms of the United States grain standards act. At the Omaha market 5,309 appeals were handled during the fiscal year; at St. Louis, 7,302; at Minneapolis, 10,876; at Kansas City, 11,534; at Chicago, 12,238; and at Duluth, Minn., 21,207 Federal appeals were entertained.

Pursuant to the requirements of the law, fees were assessed and collected on all appeals not sustained. This resulted in the collection of $85,243.98, which sum was covered into the Treasury as miscellaneous receipts.

CLEANING GRAIN AT THRESHING MACHINES AND COMBINES

Studies and experiments pertaining to the cleaning of grain at the threshing machines and combines by means of a specially designed cleaning machine attached to the threshing machine or combine so as to effect the cleaning automatically as a part of the threshing operation have been continued. This work has demonstrated the practicability of this method of cleaning grain, and has shown that the cost

of handling the grain on the farm is reduced, a higher price is received, and the screenings are saved for use as feed for livestock. Farmers have come to recognize the advantages and profits resulting from this method of cleaning grain. Assistance has been rendered manufacturers in designing special thresher cleaners with the result that several hundred of these special cleaners were manufactured and were in operation in the spring-wheat area during the 1929 threshing season.

COMBINATION CLEANING AND TREATING OF SEED GRAIN

To encourage efficient cleaning and treating of seed wheat on the farm assistance was rendered to the Minnesota College of Agriculture and to a group of farmers in California in designing and building a portable combination seed-grain cleaning and smut-treating machine. The combination machine in California was operated commercially as a community enterprise. Several additional combination machines were built by other groups of farmers and individual operators. The combination machine in Minnesota was demonstrated through operation in various centers throughout the State with highly satisfactory results. As a result of these demonstrations commercial manufacturers of grain cleaners and smut-treating machines have begun the manufacture of combination machines, which are now coming into common use. A department leaflet on the subject was prepared by this bureau in cooperation with the Extension Service, Bureau of Plant Industry, and the California State Extension service, and was published and given wide distribution.

SEED-GRAIN SURVEY

A survey was made of the seed wheat planted in the spring-wheat area. Samples of the grain that was actually being planted on a large number of farms in Minnesota, North Dakota, and South Dakota were taken from the seed drills. These samples were analyzed and tested for admixtures of weed seeds, other grains, other classes of wheat, and for smut infestation. The samples were also tested for germination. The results of these tests show that much of the grain that is planted in that area is undesirable from a high-class-seed standpoint. A report of the results of the survey is in course of preparation.

MAINTAINING QUALITY AND CONDITION OF COMBINE-HARVESTED GRAIN

Investigations pertaining to the effect on the quality, condition, and market value of grain harvested with combines were continued. Results show that grain harvested with combines is of as high quality, in as sound condition, and of as high market value as grain harvested and threshed by the older binder or header and stationary threshing machine method, provided certain precautions are observed in the combining operation.

A bulletin on the subject pertaining to wheat produced in the spring-wheat area, prepared by this bureau, the Bureau of Public Roads, and the North Dakota Agricultural College, was published by the Agricultural College of North Dakota. A similar bulletin prepared by this bureau and the Minnesota College of Agriculture was published by the Minnesota College of Agriculture.

FARM GRAIN STORAGE

In cooperation with the Bureau of Public Roads studies were made of the advantages of farm grain storage and of the types of storage suitable for use on farms. Results show that properly designed farm grain storage makes possible a system of more orderly marketing, reduces car shortages and embargoes, reduces the number of persons necessary to handle the crop, facilitates cleaning grain on the farm and at country elevators, prevents the need of piling newly threshed grain on the ground, facilitates conditioning of grain before selling it on the market, and enables farmers to sell wheat on a protein basis. Department Leaflet 46, entitled "Farm Grain Storage," was published.

RICE-GRADING SERVICE

Practical assistance has been given to the rice growers through the inauguration of cooperative grading services in Texas and California and in bringing about widespread use of the grades for rice recommended by this bureau. The Department of Agriculture of the State of California reported that since the Federal-State rice-grading service had been put into operation rice had been shipped to foreign countries which had never before been considered as markets for rice from California, and that for all the lots exported on the basis of the in-

spection certificates not a single complaint of quality or grade had been received.

Under agreement with the State of Texas, approximately 1,200,000 barrels of rough rice were graded by a licensed grader. In addition to using this service in the marketing of the crop, the American Rice Growers' Association furnished each grower with a copy of a grade certificate showing the quality of his product. Rice growers, as well as officials, of the cooperative associations, stated that the grading service was of great assistance to them.

The grading work has made it possible to compile useful statistical data relative to the quality of the crop in various sections. The growers, through their cooperative associations, are formulating a crop-improvement policy. At the suggestion of this bureau, a policy of testing each grower's seed was adopted by the association, with the result that much inferior seed was replaced by seed of better quality.

Further educational work was done on methods of handling, drying, and storing rice. A rice-scouring machine was devised by an employee of the bureau which removes the bran from the rice in order that a sample of rice may be graded with greater accuracy.

BULK HANDLING OF GRAIN AND RICE

Investigations pertaining to the bulk handling of grain and rice on the farm and at the country stations in the Pacific coast area were continued. Grain and rice produced in that area are still largely handled in sacks. Considerable progress is being made in changing over from the sack to the bulk method of harvesting and handling grain and rice. The investigations completed so far show that, by handling in bulk, material savings can be made in the time, labor, and cost of producing the crop; and that further economies are effected by marketing the crop in bulk. When grain and rice are sold and delivered to the terminal markets in bulk, savings are made in that sacks need not be purchased, less labor is required, and weighing and inspection charges are less than for sacked grain. The smutting charges for smutty wheat in bulk are less than for smutty wheat in sacks. Grain can be loaded into and unloaded from railroad cars and elevators at a lower cost when in bulk than when in sacks. The cost of loading export grain into ships is less for bulk grain than for sacked grain, and in addition the speed with which grain in bulk can be spouted into the vessels frequently saves heavy demurrage charges for the vessels. The agricultural engineering division of the University of California is cooperating in the bulk-handling investigations.

DIVISION OF DAIRY AND POULTRY PRODUCTS

ROY C. POTTS, *in charge*

RESEARCH PROJECTS

A study of wholesale egg quotations in San Francisco and an analysis of factors relating to price of Pacific Coast White Extras has been carried on to determine whether the use of the San Francisco wholesale market quotations for eggs, as the basis both for buying eggs from producers in central California and for selling is fundamentally sound. It is aimed also to ascertain whether influences are in operation which prevent the market quotations on the San Francisco market from reflecting true wholesale market values, and if this be true, to suggest modification in the exchange rules and market practices which will relieve such conditions. A local study is being made of price problems affecting the New Jersey egg production.

A comprehensive study was begun on the measurement and analysis of the factors which influence the price of eggs. Average monthly prices have been compiled and price differentials are being studied.

Studies are under way covering both rural and urban per capita consumption of dairy and poultry products. These studies require the compilation of extensive statistics, only a part of which are readily available. These studies are making available information which shows the trends of demand and consumption. A detailed study of consumption and utilization of dairy products is being carried on in six selected townships in New Jersey, and a study of consumers' habits and preferences for eggs is being undertaken in cooperation with the University of Illinois.

BUTTER-GRADING SERVICE

The butter-grading service available at Washington, D. C., San Francisco, Los Angeles, New York, Boston, Chicago, Philadelphia, Minneapolis, Duluth, and Bellingham, Wash. The

work at New York, Chicago, and Washington, D. C., is Federal. At Minneapolis, Duluth, San Francisco, Los Angeles, and Bellingham the services are Federal-State in character. At Boston and Philadelphia the services are carried on in cooperation with local produce exchanges. In all cases supervision of the conduct of the grading work rests with the Department of Agriculture at Washington. During the fiscal year a total of approximately 130,000,000 pounds of butter was graded, as compared with about 120,000,000 for the previous year. This amount is nearly 10 per cent of the total annual butter production of the United States. A number of additional firms received approval of applications for the use of certificates of quality in individual packages during the year.

CHEESE-GRADING SERVICE

Cheese-grading service is available at all markets at which butter grading is carried on, with the exception of Duluth, Minn., and Bellingham, Wash. The cheese-grading service has not yet developed into a large project. Total quantities graded during the year were about 550,000 pounds. This is an increase of nearly 200,000 pounds over quantities graded the previous year. Preliminary work has been done in connection with a proposed cheese-grading service in Wisconsin in cooperation with the Wisconsin State Department of Markets. This service is intended to cover fancy aged American cheese, and each cheese is to be stamped with the grade.

EGG-GRADING SERVICE

Egg-grading services are available in New York, Chicago, Boston, Philadelphia, San Francisco, Los Angeles, Washington, Detroit, Parkersburg, W. Va., and at eight points in Virginia. In the large terminal markets this service is carried on either independently or in cooperation with some other agency such as the State, the produce exchange, or the board of commerce. The grading services at country points in Virginia are carried on in cooperation with the State Bureau of Markets. During the past fiscal year there were graded at these various points a total of 335,000 cases of eggs.

The work in West Virginia, in Virginia, and at Detroit, Mich., was developed during the year. Plans were completed for the inauguration of an egg-grading service at Seattle, Wash., and one at Portland, Oreg.

POULTRY-GRADING SERVICE

A regular poultry-grading service is carried on in Washington, D. C. Approximately 114,000 pounds of poultry was graded for the Marine Corps and for hospitals of the Interior Department and the Veterans' Bureau.

It is planned in the near future to hold hearings at several points in the United States on the tentative United States standards and grades for poultry. It is planned to extend the poultry-grading work to markets where there is a call for it and where egg-grading services are already in existence.

TURKEY-GRADING SERVICE

An interesting grading service on turkeys has developed during short periods just previous to Thanksgiving and Christmas. This work was first undertaken in Washington in 1927. The turkeys were examined individually, and those which met the specifications for United States prime were so stamped on their backs. In addition they had attached to the wing a tag giving the grade and a statement of the purpose of the grading. The turkey-grading work at that time was so successful that it resulted in a demand greater than the facilities of the bureau could supply. In 1928 more than 1,700,000 pounds of turkeys were graded at about 10 points in cooperation with State agencies.

POULTRY-INSPECTION SERVICE

The poultry inspection service consists of the live-poultry-inspection work at New York and the dressed-poultry inspection for condition and wholesomeness at various points in the East and Middle West. This inspection service differs radically from the poultry-grading service. The live-poultry-inspection work is confined to New York City and near-by terminal points. The purpose of the inspection is to determine if the live poultry received for use in New York is in a healthful condition and that it has not been overfed. This work is carried on in cooperation with the New York Live Poultry Commission Merchants' Association, which acts as the fiscal agent, receives the fees charged for the service, and disburses them to meet the costs of the service.

The bulk of the poultry inspected is received in car lots from various points in the Middle West and South. During the past fiscal year there was in-

spected in New York and vicinity the equivalent of 12,139 cars of live poultry.

The dressed-poultry inspection service is a new development. It consists of the examination of each poultry carcass upon evisceration. It was begun originally for poultry which was to be used in the preparation of various canned poultry products. All costs of the service are borne by the plants receiving it. Poultry products canned in an establishment where the poultry is inspected are put up under labels which bear the inspection legend of this bureau. During the last few months there has been a strong demand for the extension of this service to middle-western points, as a result of which the bureau has established a supervision office at Chicago.

During the past fiscal year there were inspected at the points where this service is in effect over 10,000,000 pounds of poultry. It is interesting that the demand for canned-poultry products seems to be increasing rapidly. It is probable that the inspection service has had an influence as it has been a factor in creating confidence in the canned-poultry products.

RESEARCH REGARDING STANDARDS

The investigation work in the technical phases of poultry and egg marketing has been confined primarily to the formulation of standards and grades for poultry products. Decided progress has been made in the development of the grades for dressed poultry, and during the last year some modification has been found to be necessary. These standards and grades have been redrawn and are now ready for further try out and for hearings which may be held in the near future.

The grades for turkeys are a part of the general United States grades for poultry. They have received a more extensive try out than some of the other poultry grades. As the result, they have been revised to provide a greater number of grades than was originally intended. It is expected that the turkey-grading work this coming fall and winter will bring about the formulation of these grades in final form.

The United States standards and grades for eggs have been in tentative form for a number of years and have received rather extensive use. Recently a slight change was made in the United States standards applicable to individual eggs, and a change was made in the grades for use in the retail trade, designed to bring about simplification and to meet the needs of the industry.

DEMONSTRATION WORK

Egg graders have been instructed at all points at which the service is maintained. As the result, a number of qualified graders have been licensed, and assistance has been rendered to the State egg inspectors in connection with the work with which they are charged. Two small schools were held for the purpose of instructing turkey graders, and a number of men were qualified for turkey grading. The interest in United States standards and grades for eggs at points in the various States continues strong. Numerous requests have been received for material describing and demonstrating these grades, and actual demonstrations have been made in a number of States.

MARKET NEWS SERVICE

Milk and cream market reports have been inaugurated at Philadelphia. These reports will be similar to those issued at New York except that since over 50 per cent of all of the milk received at Philadelphia comes by motor truck, special arrangements have been made direct with the milk dealers to obtain information regarding the quantities of milk received at Philadelphia by trucks. These reports show the State in which all shipments, truck and rail, originated, and in the case of cream they are proving to be of considerable interest in showing sources of supply.

A live-poultry market report has been inaugurated at Chicago. This report shows receipts of live poultry by States of origin, cars on track each morning, cars unloaded each day, and the percentage make-up of cars. The latter information is obtained at New York through the cooperation of the live-poultry inspectors, but at Chicago it is necessary to obtain such information directly from the receivers.

A branch office was opened at Los Angeles during the year, this office being in charge of a representative who handles joint grading and market-news service work. The information collected at Los Angeles relates entirely to the market receipts, storage movements, and miscellaneous information secured from trade sources, but does not include price reporting.

The car-lot egg-shipment report has been extended to include Utah and Idaho, as well as California, Washington, and Oregon. The arrangements with the transportation agencies provide for a weekly report showing the number of cars shipped, the shipping point, and the destination.

A monthly egg and poultry market report has been issued beginning with January, 1929. It contains a discussion of egg and poultry markets and the cold-storage movements, and market receipts of eggs and poultry this year and in previous years are graphically shown. The report contains information regarding imports and exports, and each month a paragraph gives information of current interest and importance.

A new project regarding hatcheries was undertaken during the spring of 1929. The purpose was to gather information regarding the capacity of commercial hatcheries in the United States, the number of eggs set each month, and the number of salable chicks hatched each month. Such information will be of value in measuring the poultry population from year to year and in forecasting probable egg production.

Changes which have been occurring in the dairy industry for several years, such as expansion of direct merchandising and large mergers that have reduced the quantity of open wholesale trading, have brought the decision that the work in Wisconsin can be handled as successfully from Chicago as from Plymouth. The discontinuance of the office will cause no change in the type of service, except the discontinuance of wholesale prices at primary markets.

DIVISION OF HAY, FEED, AND SEED

W. A. Wheeler, *in charge*

SEED-VERIFICATION SERVICE

The seed-verification service will complete its second year of operation in October, 1929. The service has been limited to alfalfa seed during the past year, but following the Seed-Verification Conference in Chicago in June, it was agreed to include red clover, as it has been found that a large quantity of the seed sown in certain sections is giving poor results because it is not adapted to the climatic conditions of such sections.

Much publicity has been given this service by various agencies and an increased demand for verified-origin seed has been noted in many sections where verified-origin dealers and agronomists of State institutions have advertised the service and stressed the importance of the buyer's knowing the origin of his seed. Certificates covering approximately 31,000,000 pounds of alfalfa were issued during the year.

This service has made it possible for a farmer to obtain alfalfa seed of the desired origin at little or no advance in price. More than 85 per cent of the alfalfa seed sold is handled by verified-origin dealers. It has brought about the keeping of better records by seedsmen, and will tend to eliminate dealers whose records are inadequate. It has tended to discourage the mixing of seed from one State with that from another State and has increased the premiums paid for hardy and adapted seed. It is believed that fairer competition will be brought about and dishonest practices greatly reduced.

SEED-REPORTING SERVICE

During the year 190,000 mimeographed copies of seed reports were issued and distributed to growers, country shippers, seedsmen, consumers, newspapers in seed-producing districts, agricultural periodicals, and others, by the seed-reporting service. The four main types of seed reports covered situation, price and movement, shipment, and weekly seed reviews.

Situation reports were based on information obtained from approximately 8,000 country shippers and 30,000 growers, which was supplemented by that obtained from State agricultural statisticians and by personal visits to seed-producing districts. Foreign information was acquired through contact with foreign correspondents.

Other reports such as prospective seed demand, retail seed prices, retail seed sales, and certified seed-potato production were issued. Special reports and services covering vetch, ryegrass, and sunflower seed were issued. Demand for special service was greater than usual and included the preparation of magazine and newspaper articles, radio talks, the assembly of data and other information for use in conferences with other bureaus, departments, governmental agencies, and commercial associations, largely with respect to tariff revision, weed control, seed production, and marketing.

The seed-reporting service was again of assistance to the Red Cross in locating seed supplies for storm-swept areas.

HAY STANDARDIZATION

A special campaign of educational work has been conducted on the methods of harvesting, baling, and storing necessary to the production of high-grade alfalfa hay. Farmers' Bulletin No. 1539, High-Grade Alfalfa Hay: Methods of Production, Baling, and Loading for Market was prepared and distributed among producers and shippers of alfalfa hay in the most important alfalfa-producing States.

Hay-grading demonstrations have been held before producers, dealers, and feeders of hay, at many points throughout the hay-producing States. In cooperation with the Chicago International Livestock Show and various State colleges, a hay-judging contest was held in connection with the Chicago show, and instructions given to college students and others on the Federal grades. A contest was held for colleges in Western States, and an exhibit was made at the Pacific International Livestock Exhibition. An exceptionally large number of type samples of hay were prepared for the use of State workers, shipping associations, and hay exchanges in demonstrating the United States standards.

Work has been continued on the measurements of hay in stacks for the purpose of formulating rules for determining the volume of hay in stacks and the number of cubic feet of hay necessary to make a ton. Since large quantities of alfalfa hay in the Western States are sold in the stack, accurate rules for determining the number of tons in such stacks are of great importance. During the last two seasons data have been obtained from 2,461 stacks, and these data are being tabulated and analyzed. This study will be completed as soon as possible.

Definite progress has been made in developing new equipment for measuring color of hay. The use of artificial light, methods of handling samples, and methods of making color readings have been studied thoroughly. New equipment is being developed which is more simple to operate and more accurate in its readings than that previously employed.

ALFALFA-MEAL STUDIES

A preliminary field survey has been made for the purpose of laying the foundation for the preparation of alfalfa-meal standards. A representative of the bureau visited a number of the important markets and grinding centers and held conferences with reference to the grading factors and inspection methods wanted by the trade. Extensive laboratory research will be necessary before standards can be established.

SOYBEAN HAY STANDARDS

Following a period of research work on soybean hay, conducted in cooperation with the Alabama Polytechnic Institute and the Alabama Farm Bureau Federation, hearings were held, and tentative United States standards for soybean hay were promulgated. This work has been of great interest throughout the soybean-producing area. The United States standards have been adopted as the official standards in Alabama and are being used at important terminal markets for this product.

BEAN STANDARDIZATION

A check has been made of samples of beans from lots sold under commercial standards which indicates a need for a wider use of United States standards and closer Federal supervision of inspection. At the request of various growers' associations and others, brief circulars have been prepared explaining the grading factors and showing the advantage to be obtained through the use of the United States standards as a basis for contracts for the sale of beans. These have been given wide circulation among both bean growers and dealers.

Tentative standards were issued for butternut beans, effective October, 1928. These standards have been used as a basis for inspections in Idaho and have been found satisfactory. After another year's trial they will be made a part of the United States standards for beans.

INSPECTION SERVICE

The inspection service on hay and beans showed a normal increase during the year. Because of a short crop, broomcorn moved to market quickly, and there was only a small demand for inspections. During the year six new agreements for inspection work in cooperation with States or commercial organizations were entered into, and four additional agreements are under consideration. The work of training inspectors for the War De-

partment has continued, and a larger number of commercial inspectors have been licensed than in previous years. Very few complaints or appeals from grades assigned by licensed inspectors have been received. The inspection service has continued to serve as a means for suggesting improvements in marketing methods and practices. Assistance has been given to State officials in drafting legislation relating to the inspection service.

A marked increase in the number of soybean inspections resulted from the placing of contracts for soybeans by large crushers in Illinois on the basis of the United States No. 2 grade. During the year, Peoria, Ill., has developed into the largest receiving market for soybeans in the United States. All receipts at this point were federally inspected.

MARKET-NEWS SERVICE

The market-news service on grain, hay, and feed has been expanded. New offices have been opened at Portland, Oreg., San Francisco, and Los Angeles; the offices in California are operated in cooperation with the State. This makes the service more nearly national in scope since the organization now covers all the important grain and hay producing areas. Previous to this year, the service was confined largely to the East and Middle West. Information was available to the Pacific coast before these offices were opened, but the service did not cover the coast completely. With the new offices it will be possible to extend to the agricultural interests of the Pacific coast comprehensive information relative to the market situation in that section on grain, hay, and feeds.

Another important development was the inauguration of a market-news service on rice for the growers of Arkansas, Louisiana, and Texas. This service is now providing weekly information relative to the market situation on both rough and cleaned rice, and plans are being made for the collection and compilation of statistics relative to stocks and movement of rough and cleaned rice, which will enable the bureau to provide the growers with a monthly statement of movement and supply. Such information will help growers in developing a marketing program. The service has been favorably received by the rice growers. The manager of the largest association of growers in the South has stated that the market information was helpful to them and has sent an earnest request to the bureau that the service be enlarged and continued. Plans for the coming year provide for a sufficient enlargement to cover all the rice-growing areas of the United States. It is hoped to provide more information relative to the supply and demand of rice in competing countries.

The news service on broomcorn was enlarged to cover the principal broomcorn-growing districts and to include a report on the market situation at all important markets. Weekly reviews were issued during the principal marketing season and monthly reviews during the winter and spring when movement was light.

DIVISION OF WAREHOUSING

H. S. Yohe, *in charge*

There has been a continued increase in licensed cotton-storage capacity. On July 22, 1929, this figure reached 3,760,500 bales. Through these licensed warehouses approximately one-half the total cotton crop is handled. Some of the largest cotton warehouses of the world are under Federal license, among them being the public warehouses at Memphis and New Orleans.

A moderate increase was made in licensed space for storing grain, the total capacity being approximately 36,370,000 bushels on July 22, 1929. In connection with the grain work a terminal elevator with 1,200,000 bushels capacity was licensed at Omaha, Nebr. A wool warehouse at Columbus, Ohio, having a capacity of about 4,875,000 pounds of wool, was licensed. This warehouse serves the wool-marketing agencies of the Ohio, Indiana, and Michigan farm bureaus.

The number of warehouses storing tobacco, canned foods, and other products remains about the same as during the previous year. The largest tobacco storage in the country is operating under the Federal warehouse act. Warehousemen storing canned foods have rendered a real service to their patrons. Without exception, canners who have used the warehouse act have been outspoken in their praise of this service.

The placing of cold-pack fruit on the eligible list for storage under the warehouse act has resulted in serving to a high degree the packers of berries in the Northwest, particularly the cooperative associations. Licensed capacity for handling this commodity has more than doubled during the year.

INSTALLATION OF GRAIN-REGISTRATION SYSTEM

Early in June, 1929, arrangements were made in cooperation with the Enid Board of Trade for registering through a registrar, responsible to the department, all grain entering certain licensed elevators at Enid, Okla. This system was installed so as to make the grain paper originating at that point acceptable for rediscount to the Federal reserve bank serving that district. Through this arrangement the local banks are enabled to finance more adequately the grain producers and dealers of that section.

CANNED-FOOD STANDARDS

Standardization work for canned vegetables was continued during the year. The tentative standards for canned peas, corn, and tomatoes were further improved. The Wisconsin Bureau of Markets adopted the tentative standards for canned peas as official State standards, and more than 50 per cent of the peas packed in Wisconsin last year and this year are packed in accordance with those standards. Many canners are experimenting with the grades developed under those standards. Further work was done in connection with the standards for canned spinach, string beans, lima beans, succotash, and pumpkin. These standards will be further improved, although at this time they are being used by many canners.

DEMAND FOR ADDITIONAL PRODUCTS

During the past year requests continued to come to the department to place additional products on the list of commodities eligible for storage in federally licensed warehouses. Among these were alfalfa seed, English walnuts, filberts, pecans, cherries processed in sulphur and brine, and raw apples. Preliminary consideration and investigation have been given to some of these products.

DIVISION OF STATISTICAL AND HISTORICAL RESEARCH

O. C. Stine, *in charge*

FOREIGN COMPETITION AND DEMAND

Information relating to foreign crop and market conditions is now being collected annually through the established offices of the Department of Agriculture in foreign countries, the Consular Service of the Department of State, the foreign service of the Department of Commerce, and the International Institute of Agriculture. An exchange of information directly with governments and with private agencies adds materially to the information collected through the above channels. The Consular Service contributes timely cables on shipments to the United States, crop prospects, stocks at important points, prices, and other important information about the markets, and more extensive written reports concerning crop and market conditions. In the past year Consular Reports have averaged more than 600 per month, making a total of nearly 7,500 reports for the year. The foreign-service officers of the Department of Commerce also have contributed information as to agricultural conditions in foreign countries, stocks, and particularly economic conditions affecting the demand for agricultural products.

Producers in the United States need information about the production in foreign countries and the demand in foreign markets as a basis for planning the production and marketing of their products. It is also obvious that they need the information as to the probable outturn of production and probable demand as early in the season as possible. The data obtained are combined with the crop and market reports of the bureau and are given wide dissemination. Some progress has been made in checking the early official forecasts and in making forecasts in advance of official forecasts, but much more can be done. Very little has been done in measuring or forecasting demand, and much needs to be done in this field.

Particular attention has been given to the publication of information on the prospects of the wheat crops in Canada, Argentina, and other important wheat-producing countries. The relation of fall and winter climatic conditions to yields was analyzed for the Canadian crop, and these conditions were found to be important in determining probable yields. Significant facts were published in advance of the harvest with regard to probable yield of wheat in foreign countries, which have been of benefit to American farmers in marketing their crop.

Recognizing that durum wheat has a special foreign market, an analysis has been made of durum wheat production and prices. All available data have been collected as the basis for estimating the production of durum wheat in foreign countries. An analy-

sis has been made of the relation of production to prices, and a better basis has been developed for forecasting the demand for durum wheat.

The foreign market reporting service has been expanded along several lines. Special efforts have been made to improve the reporting service on wool. The American consul stationed at Bradford, England, spent some time in the bureau learning its needs for information. The result was a reorganization of the reporting from that station. Arrangements were made with the bureau's London office for cabling additional information including prices; quantities of wool, tops, and yarns passing through conditioning houses at Bradford; and exports and imports of wool and wool manufactures. Similar information is being obtained from continental European countries through the Berlin office. The consul at Tientsin, China, in accordance with arrangements made by the bureau's representative, cables arrivals, stocks at important points, condition of transportation facilities, prices, declared exports, and other significant information about the Chinese market. A beginning has been made also at collecting and distributing information concerning carpet wool in other parts of the world.

Producers who have had to meet competition with products from the Mediterranean Basin have asked for additional information. The North Pacific Nut Growers' Cooperative Association asked for a special report on filberts, to be used in planning the marketing of the present crop. Consuls at Tarragona, Barcelona, Naples, Messina, Palmero, and Constantinople responded promptly to requests for information and reported stocks, prospective supplies, and prices. The walnut growers needed more information from the Orient. The agricultural commissioner canvassed the situation and arranged for reports on stocks and prices from Tientsin. In the course of the year additional information was supplied to almond and prune growers.

The bureau sent a specialist in dried-fruit production and marketing to Europe to study the factors affecting the market for American dried fruit, particularly prunes, in Europe and the trend of competition in European producing areas. Both the Washington staff and the Berlin and London offices of the foreign service have worked closely with the investigator on this project. The Yugoslav prune-producing districts were visited, and the contacts thus made have proved valuable to the Berlin office in reporting on the Yugoslav crop. Important changes have taken place in Yugoslav prune production since 1925, when a survey was made by this bureau. The investigation of the past year disclosed these changes and provides a valuable picture of the competitive position of the Yugoslav prune industry.

A new service on honey has been inaugurated, since the foreign market has become important to honey producers in the mountain and Pacific Coast States. Plans are being developed to provide these producers as much information as possible with respect to European markets.

A beginning has been made for providing more adequate service on bean production in foreign countries. Data have been collected as to production in important producing countries. Records of imports and exports have been compiled. Basic reports on bean production and marketing were obtained from consular officers in the principal foreign bean-producing countries. Some much-needed information on the competitive influence of different kinds of foreign beans on the various American beans has been obtained. Arrangements have been made with consuls for regular reports on production and market conditions in important centers in foreign countries.

The California market-news service has called for information concerning foreign production and foreign market conditions that affect the marketing of the many different agricultural commodities of that State. In many cases these requests have required an expansion of the bureau's information service. A large number of California producers have been reached directly or indirectly through this service as well as many producers in other States.

Studies of foreign competition and its effect upon the demand for pork products have been continued. It is of interest to note that in the past few months there has been a strong demand for pork products owing to reductions in the production of pork in several north European countries. This was anticipated by this bureau. There is now evidence of a tendency to increase production. It is obvious that the pork-production cycle in northern Europe is fairly closely in line with the cycle in the United States and that the demand for pork from the United States in north European markets will meet increasing competition within the next 18 months.

A decline in the foreign demand for cotton in the latter half of the year

considerably reduced the exports of American cotton and probably was a factor in causing a decline in cotton prices in the latter part of the year. The Berlin office has kept the bureau informed of the manufacturing activity and of the demand for goods in many continental European countries throughout the season. From these reports the decline in the demand could be anticipated by American producers. The Shanghai office has furnished information on conditions in the Orient. The depressing influence of a larger Indian crop and of declining demand in central European countries has been partly offset by increased consumption in the Orient.

The greatest need for improvement in marketing American apples abroad now appears to be in regulating shipment so as to avoid gluts. An analysis of the effect of heavy shipments upon prices is being made to show producers and shippers the losses that result from a failure to distribute their shipments evenly and in relation to the demand for apples.

The foreign-service section has assisted in the preparation of outlook and price-situation reports and has prepared during the year 375 press releases, 360 foreign-service reports, and 52 issues of Foreign Crops and Markets. The mailing lists of the special foreign-service reports contain over 8,000 names and the Foreign Crops and Markets mailing list over 2,600 names. Both the special foreign-service reports and Foreign Crops and Markets are extensively republished in newspapers and used by State agricultural economists and statisticians. Farmers and farm leaders are appreciating more and more the value of information relative to foreign competition and demand, and their demands for this service are increasing.

AGRICULTURAL-OUTLOOK STUDIES

An increase in funds has made possible an expansion in collecting and analyzing data for use in the preparation of production and marketing programs. A beginning has been made in studies of factors affecting the prices of stocker and feeder cattle as a basis for aiding cattle feeders to plan their business so as to avoid losses. This becomes particularly important at the present phase of the cattle cycle. Prices have risen to a high point, and while they were rising it was easy to make money feeding cattle and there was but little chance of losing. Now with the prospect of increasing cattle production and lower prices within a few years, feeders are facing some difficult situations and need a better basis for judging what price they can afford to pay for feeders, or what they can expect to obtain for the fed cattle when they are ready for market. A similar analysis of lamb prices has also been begun. Hog prices have received much attention, but there are still important points to be investigated, and some attention is being given to developing more accurate estimates of the probable supplies of hogs.

A beginning has been made in the analysis of egg prices. The relation of egg receipts to prices has been studied. Preliminary results have been used in the first midsummer outlook report on eggs and poultry and in the preparation of egg price situation reports, which began in April.

Rice is another commodity upon which little research work has been done in preparation for outlook reports. Much information has been gathered as to the production, distribution, and prices of rice and the most important factors influencing prices have been determined. The analysis has not been completed, but enough work has been done to provide a much better basis for planning both the marketing and production of rice.

PRICE ANALYSIS

Analyses of the prices of farm products have been continued. Additional work has been done on corn, oats, and wheat. The results of the analyses have been used in the monthly price situation reports. Study of corn prices has included the determination of the average level of corn prices for the crop year and the intraseasonal changes. It has been found possible to ascertain fairly accurately the December price of corn and the change from December to May. Oat prices are being studied in relation to the prices of other feedstuffs. Some time has been devoted to revising the formula for estimating the May price of wheat. Studies have been made of the relation of world supplies of wheat to world market prices and the relation of the supplies of the different classes of wheat in the United States to world market prices and to the prices of other wheats in this country. These studies will develop the basis for determining the general level in seasonal movement of prices for the different classes of wheat in the United States.

The analysis of apple prices has been continued, and the results are being

utilized in the preparation of monthly price-situation reports. Work on potato prices has been inaugurated.

Progress has been made in the collecting of data and in the making of a preliminary analysis of wool prices. The course of prices of cotton during the past season will be reviewed to show what factors have influenced the price level and the price changes.

A project dealing with factors that determine the price of butter was begun some time ago at the University of Minnesota and is being continued in Washington. An analysis has been made of the factors affecting the number of milk cows in different States as a factor in determining butter production. A study of the probability of expanding the dairy industry in the different States has been begun. The relation of pasture conditions to summer production and feed prices to winter production has been analyzed. It is hoped that these studies will be completed for publication in the coming year.

A study of the factors affecting the consumption of dairy products was undertaken in cooperation with the New Jersey experiment station. An enumeration of the consumption and production of dairy products in six selected townships in northern New Jersey has been completed. The purpose of this enumeration was to find first of all the per capita consumption of dairy products in different forms under different conditions. These per capita consumption data will be useful in estimating both the production and consumption of dairy products throughout the country. A survey was made of the consumption of dairy products in Jersey City. The object was to ascertain the effect of variations in racial characteristics, composition of the family, income, and other measures of living conditions upon the consumption of dairy products.

A study is being made of the causes of variations in the demand for dairy products in New York City through collecting data on sales by chain stores in different parts of the city, and relating these sales to income and nationality groups.

MONTHLY PRICE-SITUATION REPORTS

The price-situation reports of the bureau have been improved both by increasing the number of commodities dealt with and by making a more critical analysis of the different commodities. A review of forecasts made during the past year shows more definiteness and a fairly high degree of accuracy in forecasting the prices of most of the commodities two or three months in advance of the report. The mimeographed report was inaugurated primarily for the benefit of State statisticians and economists, who wanted the report promptly for use in preparing monthly State-outlook or price-situation reports. It is evident that the monthly price-situation report is meeting a need for a continuous outlook and price-situation service to supplement the annual and seasonal outlook reports as a basis for planning both production and marketing during the year.

AGRICULTURAL INCOME

Research aiming at improvement in estimates of agricultural income has been continued in cooperation with other divisions of the bureau. Estimates of gross income from production by States have been nearly completed. The next step is to collect data and estimate expenses by States. This will require another year or more of work.

The annual income from farming in the United States during the past season has been estimated in the usual manner. The aggregate gross income for the 1928–29 season is estimated at $12,527,000,000, an increase of about $225,000,000, or nearly 2 per cent over the previous year. During the past season producers of livestock and livestock products have realized better incomes, but wheat and potato growers received less than during the previous season. Expenditures for feed, fertilizer, and machinery during the past season appear to have been a little larger than during the previous season. Consequently the net income and the return on capital has been increased but little.

TRANSPORTATION RESEARCH

A study of the transportation of cotton has been continued. Special problems have been dealt with in response to requests of farmers, farm organizations, and others for information concerning freight rates in relation to agriculture. A study of the effect of changes in freight rates on production and prices has been continued. The purpose is to determine to what extent and under what circumstances farmers pay the freight rate and how the adjustments or changes affect the farmers' income.

TARIFF STUDIES

The proposal to revise the tariff act of 1922 gave rise to the demand for information from this division, the supplying of which required a large amount of work. Many requests have been received for information as to exports, imports, character of competition from foreign countries, tariff duties, and the effect of rates or the probable effect of proposed rates upon imports or prices of products. In response to requests, information regarding the production and trade in all important farm products have been tabulated and analyzed in relation to the tariff. For each of the important commodities and groups of commodities a study has been made of the effect of the tariff on imports and prices and the probable effect of changes in duties. Special studies were made in response to specific requests.

HISTORICAL RESEARCH

An agricultural history bibliography has been completed. This carefully selected but comprehensive bibliography will be useful to those engaged in economic research and to other agricultural-research workers. History gives the agricultural student and research worker a better perspective and provides a basis for better judgment in dealing with agricultural problems. The teaching of agricultural history has made but a modest beginning in this country, but it is believed that there will be a rapid development in this field in the next few years.

The collection and analysis of farm prices in Virginia and Maryland over a long period of years has been completed. The results of the Virginia study are in press as a bulletin of the Virginia Agricultural Experiment Station, and the University of Maryland will publish the results of the Maryland study as a station bulletin in cooperation with the Bureau of Agricultural Economics.

DIVISION OF AGRICULTURAL FINANCE

ERIC ENGLUND, *in charge*

AGRICULTURAL CREDIT AND FINANCE

Research in agricultural credit during the past year has developed significant facts concerning the demand for farm credit and means of improving the farmer's credit practice. The importance of the farmer's borrowing operations has been emphasized by results of studies in short-term credit conducted in a number of States and of nation-wide investigations in farm mortgages. These inquiries have shown that approximately 75 per cent of all farms use seasonal credit and that about 37 per cent of farm owners use credit secured by farm mortgage.

Analysis of the factors affecting the demand for credit on individual farms has shown significant relations between farm credit problems on the one hand and size of farms and systems of farming on the other. Although the amount of short-term credit per farm increases with the size of the farms, the amount per acre decreases under substantially similar conditions of farming. The same relation appears in the field of mortgage credit; the ratio of debt to value of the farms mortgaged decreases with the increase in the value of the farm. For the country as a whole in 1925, mortgaged farms under $2,500 in value have indebtedness of 50 per cent of their value, while those over $50,000 in value have debt of only 36 per cent of their value. Further study of demand for credit is in progress.

Studies in farm-credit risk have aimed to determine the causes of the spread between money rates on the central markets and credit costs to the farmer in selected areas. Results show that, despite some poor risks, credit charges to many individual farmers often bear little relation to the danger of loss to the lender, but are more nearly related to the type of institution supplying the credit. One-half of the farmers using credit in some representative areas pay moderate rates on half their short-time credit and four times that amount on the other half.

Studies of merchant credit among cotton, tobacco, and potato growers show that many farmers often fail to realize the high rates of interest they pay on fertilizer and on general supplies bought on time. Thus studies made in the cotton and tobacco areas of North Carolina, South Carolina, and Georgia indicated that fertilizer at time prices generally cost the farmer around 35 per cent interest on an annual basis. Eighty-two credit merchants interviewed in these States and in Arkansas and Oklahoma reported charges which averaged 27 per cent per annum on all credit sales to farmers, and occasionally charges averaged in the neighborhood of 80 per cent per annum. Such rates are not a net gain,

since the losses of these 82 merchants on credit sales to farmers over a 4-year period equaled 15 per cent, leaving a gain per annum of 12 per cent. Thus, this practice is the source of serious waste for those farmers who pay their bills. It tends to subsidize submarginal producers and thus increases the output and thereby lowers the price paid to producers generally. The outlay for credit due to such charges, in excess of cash rates, has been found to be nearly equal to the tenant's annual rate of accumulation.

These facts suggest that farmers should shift their credit operations to a cash basis as far as practicable, and to that end should establish connections with local banks or other cash-lending institutions from which necessary production credit may be borrowed at lower rates of interest.

The year's research has aided in diagnosing various farm-credit difficulties. In the Southern States where local studies have been completed the farmers who use larger amounts of credit and who are usually better risks more often buy on time from the merchants than do farmers who use less credit. This suggests not only a limited lending capacity of local institutions but also that buying on time, despite the high cost of this form of credit, is habitual with many farmers who could avail themselves of cheaper loans. These local money shortages which hamper the farmer's operations are frequently intensified by the retention by banks of large amounts of farm mortgages among their assets. Much of this long-term credit on standard security could be shifted to other agencies specializing in farm mortgages.

Credit studies have shown that the farmer often can effect improvement by better handling of his finances. For example, approximately one-half the credit-using farm owners interviewed in North Carolina had no mortgage credit. By using land as security for long-term loans from sources specializing in farm mortgages, such farmers could obtain, at much reduced rates, ample operating funds which, with careful management between seasons, could be used year after year. This policy would relieve the demand now made on many banks, and leave those agencies in better position to serve emergency needs. The importance of care in using mortgage loans for short-term financing hardly could be overemphasized. Should the borrower yield to the temptation of dissipating these funds for nonproductive purposes, it clearly would be better not to resort to this type of financing.

It has been found that fluctuations in annual returns to farmers and other variations in local conditions affecting credit institutions are major difficulties for many local banks and credit merchants. Credit corporations in areas studied have been irregular in benefiting the farmer partly because they have not always been formed when credit conditions warranted, or, because they have been discontinued when credit cost to the farmers of the area was still high. A study of agricultural-credit corporations, now in progress, will provide a further basis for evaluating them.

Comprehensive studies of farm-mortgage debt in the United States indicate that from 1920 to 1925 there was an increase in the total volume of farm-mortgage debt on all classes of farms of more than 19[1] per cent over the $7,857,000,000 estimated in 1920, and a further increase of slightly more than 1 per cent from 1925 to 1928. The estimated total mortgage debt as of January 1, 1925, was $9,360,000,000, while the debt as of January 1, 1928, is estimated at $9,468,000,000. During the latter period more farms have been mortgaged but for a slightly reduced proportion of their 1924 value. Since 1924, however, the ratio of debt to current value has increased because of a decline in land values. The probable reasons for these changes will be explained in the full report of these estimates of farm debt.

Data concerning source of loans and their ratio to land value in the various States have furnished material for a new study of the cost of credit. Continuation of this line of research is planned in order to obtain reliable information currently on volume, sources, and cost of farm credit.

Preliminary studies of farmers' investments outside of their farms have shown that few farmers have such investments. Nevertheless these investments and their possibilities are of sufficient importance to warrant careful study. Plans are being made for a research project in this field.

During the year material concerning farm credit has been provided for use in agricultural extension on a number of occasions. Several articles have been contributed to scientific periodicals and farm journals, and a number of radio talks on farm credit have been given.

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[1] Preliminary.

AGRICULTURAL INSURANCE

The results of a comprehensive study of farmers' mutual fire insurance were included in Circular No. 54, Developments and Problems of Farmers' Mutual Fire Insurance, published in 1928. This study deals with the outstanding problems and recent developments affecting those mutual companies which limit themselves largely or exclusively to the insurance of farm property. Statistical data were obtained for 1,911 such companies, the combined risks of which amount to approximately $10,000,000,000. This volume of insurance is sufficient to cover, at three-fourths value, about 52 per cent of all insurable farm property in the United States. Through this form of organization, farmers are obtaining fire insurance at an average cost of about 26 cents per $100 per year. The study indicates, however, that if the more advanced methods and practices in use by a part of these mutuals were adopted by all the companies in this group, the present moderate cost of such insurance could be further reduced by fully one-half. This study was exceptionally well received by mutual companies, farmers, and the public generally.

Work has been nearly completed on a project which aims to bring up to date the bureau's information on fire prevention and fire protection on the farm. The study deals with control of farm fires from a threefold standpoint; namely, care in construction, maintenance, and use of property with a view to eliminating fires as far as possible; individual or home equipment for the extinguishment of fires discovered in their early stages; and organized rural fire protection including a summary of recent State legislation intended to promote such protection.

Work on the committee on farm fire protection, organized under the auspices of the National Fire Protection Association, has been continued. Two bulletins were prepared by the committee, one of which deals with fire-protective construction on the farm and the second with specifications for equipment for rural fire protection. A number of outstanding problems in fire, windstorm, and crop insurance were outlined and discussed before groups or associations of farmers and their insurance representatives. Special assistance was given in the organization of a State association for reinsurance and other purposes among the farmers' mutual companies of New Hampshire. Additional information has been gathered on the subject of livestock insurance with a view to the publication of an analytical summary of this form of insurance in the United States.

In accordance with the bureau policy of disseminating widely the results of research, various phases of the results of research in insurance have been included in radio addresses and articles for insurance journals.

FARM TAXATION

The results of six or seven years of research in the problems of farm taxation have been prepared for publication. This study includes work done in cooperation with several States, as well as research carried on independently by agricultural experiment stations.

Total taxes paid by farmers in 1927 were estimated to be $900,000,000. Taxes for 1928 were 1½ per cent above those of the previous year. Since 1914 farm taxes on land and buildings have increased more than 160 per cent. Thus the average farmer who in 1914 paid about $40 taxes on his real estate is now paying about $105.

Income from farm land in those sections in which rented land is common is best measured by the net rent which the landlord receives for his property. Studies have been made in 14 States to ascertain the proportion of net rent which the landlord is compelled to use to pay his taxes. The percentages reported by these studies varied from over 50 per cent in Michigan and New Jersey to less than 20 per cent in Missouri and Arkansas. Nine of the States reported percentages ranging from 25 to 40 per cent. It was estimated on the basis of the data assembled that during the period 1922 to 1927, taxes took about 30 per cent of the net income of rented farms.

A comparison of the relationship between taxes and net cash rent in 1919 and 1924 on farms in 20 counties of 15 States indicated that in 1924 the percentage of net rent taken by taxes was higher than it had been in 1919 in 17 of the counties and lower in 3 counties. The percentages in the individual counties ranged in 1919 from 12 to 31, and in 1924 from 15 to 72.

For the country as a whole in 1924 the tax on each $100 of actual value of real estate in owner-operated farms averaged $1.22. In the various States the tax on the same amount of value varied from 71 cents in Florida and 72 cents in Virginia to $2.07 in New Hampshire. In 26 of the States the

tax was between $1 and $1.50 per $100 of real value. Land values for the country as a whole were, in 1928, 10 per cent lower than they were in 1924, and farm taxes were 5 per cent higher. On the basis of these figures it was estimated that in 1928 farmers paid in taxes $1.42 per $100 of actual value of land and buildings.

Several cooperative studies of taxation have been carried on with individual States. The cooperation of this bureau with the tax commission of North Carolina made possible an extended treatment of the taxation of agriculture in the detailed report which the commission published early in 1929. Similar cooperation in an investigation authorized by the Legislature of the State of Iowa resulted in the presentation of a report containing detailed figures concerning the taxation of various types of businesses and properties in that State.

Cooperative research in farm taxation was carried on with the agricultural experiment stations of the States of Virginia, Colorado, Washington, and New Jersey. A report entitled "Some Colorado Tax Problems" was published by the Colorado Agricultural Experiment Station as a result of investigations in that State. Further work directed particularly toward an understanding of the costs of county government and the financing of rural schools is being carried on in Colorado. A bulletin summarizing data relating to the taxation of rural and urban real estate in Virginia is in press. The work in Virginia is being continued in the form of an investigation of certain aspects of local finance. Data secured in both Washington and New Jersey have been tabulated, and detailed reports of results for each of these States are in the process of preparation.

Material relating to farm-tax problems has been supplied to many individuals and groups interested in a serious investigation of the problem. Suggestions have been made to committees of farm organizations in several of the States to assist them in formulating programs of tax reform. The data prepared have been used in speeches before farm and other groups, radio talks, and articles contributed to tax periodicals and farm journals.

DIVISION OF COOPERATIVE MARKETING

CHRIS L. CHRISTENSEN, *in charge*

The Division of Cooperative Marketing was transferred to the Federal Farm Board by Executive order on October 1, 1929. The following statement covers the activities during the past year under the Bureau of Agricultural Economics.

The principal change in the scope of the work was caused by the increasing demand for assistance of a service nature. Many large cooperatives now make it a practice to consult the division before initiating or modifying any major policies. Consequently, there is an almost constant demand for assistance in formulating financing, operating, and merchandising policies. The trend toward centralization of sales and the federation of several cooperative units also creates demand for assistance in developing organization plans with reference to both the legal and the business set-up of the cooperatives.

Demand for service by cooperatives emphasizes the importance of the research of the division. The need for the collection and analysis of data regarding the organization and operation of cooperatives becomes more apparent as the functions and responsibilities of the associations increase. The service of the division becomes increasingly valuable as its fund of facts becomes greater. Approximately 60 per cent of the work carried on by the division at present may be classed as research, and it is highly desirable that this ratio should be maintained.

RESEARCH STUDIES

Research was continued along the four major lines: (1) Study of the development and problems of cooperative-marketing associations within each major commodity group; (2) business studies of individual cooperative associations which have been operating over a period of years, in which a detailed, critical analysis is made of organization, membership relations, pooling and accounting methods, financing, management policies, and merchandising practices of individual associations, and of the external economic factors which affect their operations; (3) research in legal phases of cooperative organization, financing of cooperatives, membership relations, and educational methods; and (4) studies of cooperative purchasing of farm supplies.

COOPERATIVE MARKETING OF GRAIN

The study of farmer-owned grain-marketing associations was continued. A preliminary report entitled "The Present Status of Farmer-Owned Grain Marketing Associations in the United

States" presented historical and statistical data regarding farmers' elevators and terminal grain-marketing associations. Unusual interest was aroused by this report, since it brought together for the first time information on all phases of cooperative grain marketing. It has given to those interested the first really comprehensive inventory of their activities. This study has helped to bring about closer cooperation among farmer-owned terminal grain-commission agencies. The report has been widely used by farmers' organizations.

The results of a study of cooperative grain marketing in western Canada were published in Technical Bulletin No. 63, Cooperative Marketing of Grain in Western Canada. Since this was published demands for addresses, written articles, and conferences dealing with Canadian experiences and their possible application to problems in the United States have been numerous. To keep closely informed on the experiences of the cooperative grain marketing associations in Canada, a further brief study was made.

A study of terminal grain markets and marketing organizations was initiated to obtain information for the benefit of cooperative associations. Production and marketing trends in the principal grain areas and States are being analyzed. Information thus obtained will be used in conjunction with data on the practices and policies of terminal grain-marketing organizations to provide a basis for advisory work with cooperative grain-marketing associations.

Research work with farmers' elevators in the spring wheat area was continued. Field work was carried on in cooperation with the States of Minnesota, North Dakota, South Dakota, and Montana, and records were obtained from about 100 farmers' elevator associations covering the 1927–28 marketing season. Data obtained in this study for 1926–27, covering expenses, incomes, and margins, were tabulated, analyzed, and submitted for publication as a preliminary report. Analysis was made of data obtained regarding hedging practices of farmers' elevators, and a report is being prepared.

Members of the staff engaged in reseach and service work in cooperative grain marketing have been called upon to address a number of conventions, institutes, and meetings and to attend many conferences. The bureau has been closely identified in an advisory capacity with several groups interested in the federation of cooperative grain-sales agencies and local elevators. The research studies have been of great assistance in providing helpful material.

COOPERATIVE MARKETING OF DAIRY PRODUCTS

The study of the organization and methods of representative fluid-milk marketing associations, and economic analyses of some of the factors affecting the operation of these organizations has been completed. Special attention was given to price plans and policies and to methods of adjusting production to demand.

Cooperative butter and cheese factories have been studied to determine factors affecting their efficiency and the more important factors in their development. Data have been collected and analyzed relative to the factors that affect the success of cooperative creameries. This material is being prepared in such a way as to be of assistance to producers in newer dairy sections. Suggested by-laws have been prepared for the use of those planning cooperative organizations. Emphasis has been given to an explanation and analysis of the factors that determine the type of creamery suitable under the producing conditions and volume existing in different parts of the country.

A study of fluid-milk marketing in the Lake Michigan west shore milk shed, particularly as related to the Chicago and Milwaukee milk sheds, is being carried on in cooperation with the University of Wisconsin. Data are being obtained on the present status, development, and shifts of these milk sheds and on causes of changes, together with transportation developments in this section.

Special attention has been given to the marketing of fluid milk, cheese, and butter. A survey has been made of 200 cheese factories in Wisconsin to determine their methods of operation and their costs. The study will cover also shifts of the cheese industry within the State because of the expansion of the Chicago milk shed and increased shipments of cream to eastern markets.

COOPERATIVE MARKETING OF LIVESTOCK

A survey of local livestock-shipping associations has been completed. An analysis has been made of the factors

that affect the operating efficiency of local livestock-shipping associations in the trade territory of the Indianapolis market. The purpose was to determine the factors and economic forces which have compelled local livestock-shipping associations to change their operating policies and practices and which have disrupted and destroyed shipping associations in Indiana and Illinois, particularly with regard to the competition which associations have experienced from commercial trucking and from direct-buying operations by packers. Special attention was given to the influence of inter-urban shipping, improved roads, and small markets on livestock-shipping associations. It is hoped that it will be possible to set up definite standards of efficiency for local livestock-shipping associations.

Service work with livestock cooperatives has included advice and assistance to the associations in working out their policies and programs and in the formulation of plans for organization or other undertakings; in preparing or criticizing special articles and other material for publication by the livestock journals and the associations; and in presentation of the work before directors and officials of cooperative associations, cooperative-marketing schools, and other meetings.

COOPERATIVE MARKETING OF COTTON

A conference was held with representatives of cotton cooperatives at Memphis, Tenn., for the purpose of discussing the cooperative cotton-marketing situation. Representatives from the 14 large-scale cotton cooperatives were present, and it was unanimously agreed that much good resulted from the exchange of experiences. An agreement was reached on 10 economic services that cotton cooperatives can advantageously perform for the grower. This is significant in that it indicates a greater consciousness with respect to the real functions of cooperative marketing. A request was made that this bureau make a comprehensive survey and analysis of the historical development, accomplishments and shortcomings, policies, and practices of each cotton cooperative.

A broad program of research has been undertaken in response to this request, covering (1) a detailed analysis of the policies and functional operations of each association; (2) membership studies for the purpose of analyzing the attitude of members, nonmembers, and opinion-making agencies as to services rendered by and expected of the associations; (3) a study of cooperative processing, especially ginning and oil milling as practiced by cotton cooperatives through subsidiary corporations; (4) an analysis of the operations of subsidiary finance corporations engaged in making production loans to members; and (5) an analysis of the experiences of the associations in purchasing production supplies as well as an investigation of the economic opportunity for expansion in this field by cotton cooperatives.

As a result of this research the bureau will not only be able to make concrete suggestions and recommendations as to desirable changes in organizations and operating practices but through intimate acquaintance with the various problems of cotton cooperatives will be in an excellent position to develop a long-time service program with the cotton associations.

COOPERATIVE MARKETING OF EGGS AND POULTRY

A general survey of cooperative egg and poultry marketing associations was begun. The survey will include a brief history of progress in cooperative marketing of eggs and poultry, and a classification of the different types of egg and poultry cooperatives that have been developed under varying conditions; an analysis of the problems of cooperative organizations, and of the business organization, physical set-up, legal relationship, and practices related to these problems, and a summary of accomplishments in this field of marketing. As the conditions under which cooperatives operate are determined largely by the conditions of production which are found in a particular section, the survey will aim to disclose what relationship exists between the conditions of production and the policies and methods of cooperative-marketing associations.

At the request of cooperative-marketing associations and extension workers in the Northwestern States, a survey of the methods of marketing turkeys was begun which is designed to show which of the various marketing practices employed is likely to yield the most satisfactory results to producers.

COOPERATIVE MARKETING OF WOOL

The marketing of wool in Australia, New Zealand, the Union of South Africa, England, and France was studied in 1927 and 1928 by a representative of this bureau, at the request

of some 30 cooperative associations marketing wool. The findings resulting from this survey have been presented in Technical Bulletin No. 124, Some Factors Affecting the Marketing of Wool in Australia, New Zealand, the Union of South Africa, England, and France. They have also been presented before numerous meetings of wool producers in the United States.

COOPERATIVE MARKETING OF HONEY

The study of the cooperative marketing of honey, begun in 1927, in cooperation with the New York State College of Agriculture, was completed and the principal findings prepared for publication.

COOPERATIVE MARKETING OF FRUITS AND VEGETABLES

A study was begun of the marketing practices of cooperative associations handling eastern grapes and of outlets and market demand for grapes produced in the eastern United States. This study includes a survey of retailers and consumers to obtain information regarding the demand for eastern grapes and preferences with regard to varieties and types of containers. It will be followed by a study of grading, handling, and marketing methods at country points to ascertain the extent to which the cooperative associations and other shippers are meeting market demands. A study was begun of the organization and operation of cooperative associations canning fruits and vegetables in western Oregon and Washington.

COOPERATIVE BUSINESS ANALYSIS

Findings of the business analysis of the Rice Growers Association of California were put into operation for rice producers of Texas and Louisiana through the American Rice Growers Cooperative Association. At the request of the board of directors of the latter association, a survey of the operations of the association was made during 1928. The resulting recommendations were adopted and put into practice in time for the marketing of the 1928 crop. Important amendments were made to the charter and by-laws, and a number of changes were made in the growers' marketing agreements.

A rough-rice grading laboratory was established, and Federal-State grading of rough rice was inaugurated. A comprehensive market-news service was also developed, which gives the growers weekly unbiased facts concerning the prevailing prices of rough rice throughout the rice belt, on the basis of definite grades. These services are carried on in cooperation with other divisions of this bureau.

A study of the Hastings Potato Growers Association, of Hastings, Fla., was made at the request of the board of directors of the association. Records regarding its various phases of operation, such as purchasing, financing, and selling were obtained, and interviews were had with about 60 per cent of the active members to determine their attitudes toward the association and their opinions regarding its operation and management. A preliminary report was made to the board of directors of the association, that they might have the benefit of the available results of analysis during the 1929 marketing season. Following this report, further analysis of the data was made, and additional information regarding the marketing of the association's commodity was obtained by interviewing representative members of the trade in three important markets. A final report was made to the board in June, 1929, and it is intended to prepare the results of the study for publication.

A study was made of the business of the Washington Shipping Association, Washington, Ind., at the request of its board of directors. An analysis was made of the organization, operating practices, and accomplishments of this successful cooperative enterprise. Attention was given particularly to membership performance, an analysis of sales methods and results, and to the methods of handling livestock. The results of this study will be made available for the use of other groups contemplating organization along similar lines.

A complete survey and analysis of the business policies and practices of the Utah Poultry Producers Cooperative Association, its relations with its members and customers, its economic problems, and operating policies as influenced by its environment, has been undertaken at the request of the board of directors of that association and the Utah State Agricultural College. The findings of the economic study of the Poultry Producers of Central California, completed in 1928, are being prepared for publication.

The study of the Producers Live Stock Commission Association of National Stock Yards (East St. Louis),

was completed and the results prepared for publication as a Circular 86, A Business Analysis of the Producers Live Stock Commission Association, National Stock Yards, Ill.

MEMBERSHIP RELATIONS AND FIELD SERVICE PROBLEMS

Three research projects in membership relations were instituted, two of which have been completed. These are a study of membership relations in the Hastings Potato Growers Cooperative Association in connection with a business analysis study of this association. The other was made for the California Walnut Growers Cooperative Association at the request of the general manager. The findings of the study of the Hastings Potato Growers Association were incorporated in the business analysis of that organization. Results of the study of the California Walnut Growers Association were reported to the board of directors, at which time suggestions were made for improving the conditions in membership relations and for a long-time educational program.

Membership relations and field-service problems of seven of the large cotton cooperative associations are now being surveyed. Some of the data collected from two of the States will be used as material for a service project in assisting at least two of the associations to set up means and methods of improving membership relations in their organizations prior to receiving the 1929 cotton crop.

Results of a study which was made of membership relations in the Prune and Apricot Growers Association were used in an educational campaign preliminary to the reorganization of that association.

LEGAL PHASES OF COOPERATION

Assistance has been given in the preparation of articles of incorporation, by-laws, marketing contracts, and other legal papers employed by cooperative associations. Many problems and questions of a legel nature have received attention both in Washington and in the field. Work has been done on legal questions incident to the economic and business study of the cotton-cooperative associations and a business analysis study of a tobacco association. This has involved an analytical study of the organization papers, operating methods, and cooperative statutes applicable to the various associations. Numerous articles, based on current decisions of the courts involving cooperative associations, have been prepared for publication in Agricultural Cooperation. Department Bulletin No. 1106, Legal Phases of Cooperative Associations, has been revised and brought up to date by the addition of a discussion of recent important statutes and court decisions affecting the cooperative movement. This bulletin has served as a guide to many groups of farmers contemplating organization.

EDUCATION AND EXTENSION IN COOPERATIVE MARKETING

Work has been done in assisting cooperative-marketing associations, cooperative extension officials, and college departments of agricultural economics in planning and carrying out programs of extension and marketing research. The extension and cooperative-marketing officials are particularly interested in short-time research projects, the results of which can be made available by the agencies conducting the studies before it is possible to have a complete report published. This type of research is of great assistance to the cooperative-marketing officials in planning their sales policies and is of benefit to cooperative associations and extension officials in developing production programs.

Eight cooperative-marketing schools were held during the fiscal year 1928–29. These schools were conducted by the State colleges of agriculture and extension services in all States except Mississippi, where the cooperative council, which is composed of representatives from the agricultural college, the cooperative-marketing associations, the State department of markets, and other educational agencies of the State, took the initiative. In all schools the cooperative associations have given their support by taking part in the program and by having their directors and their field and office employees in attendance.

Articles have been prepared for newspapers, farm papers, and magazines upon request. Short talks have been delivered by members of the division over the radio. Assistance has been given to cooperative associations in the preparation of such educational material, as lantern slides, lectures, motion-picture films, and exhibits.

One of the most effective methods of extending market information has

been by conferences with groups of State marketing specialists. An example is the cooperative extension conference of marketing specialists of the North Central States, which was held at Purdue University, Lafayette, Ind. At this conference, this bureau cooperated with State and Federal directors of extension and State extension marketing specialists in outlining a definite procedure for coordinating the State programs of extension, marketing, research, farm-management, and production specialists.

HISTORY AND STATISTICS OF COOPERATION

A survey of cooperation was made in which reports were collected from about 8,000 of the 11,400 active associations of which the division has record, and the data obtained tabulated by commodities and States. Significant information regarding the activities of the large-scale associations was also collected and arranged to show present trends in the cooperative movement. From this material a manuscript has been prepared for publication.

In cooperation with the extension service of the department, information regarding the cooperatives in those counties which have county agents was obtained. At the same time many county agents were supplied, in response to specific requests, with information regarding various phases of the present cooperative movement.

DIVISION OF FARM POPULATION AND RURAL LIFE

C. J. GALPIN, *in charge*

Twenty-eight projects have been carried on during the year in cooperation with State agencies, the State work being financed largely from Purnell Act funds. Between $90,000 and $100,000 of the funds provided under the Purnell Act were allocated to sociological research at the experiment stations of 25 States for the past fiscal year. The Division of Farm Population and Rural Life has cooperated to some extent in nearly all of the research projects of this character carried on under this act. These projects covered such studies as the composition and changes in rural population, rural community organizations, social aspects of farmers' local municipalities, and movement of population to and from farms. Eight bulletins were published during the year as well as a quarterly mimeographed report on farm population and rural-life activities, a directory of teachers of rural sociology, and numerous mimeographed releases on various phases of the work.

SOCIOLOGICAL-RESEARCH PROGRAM

The division has assisted the Social Science Research Council in the preparation of a monograph report on the subject of extension projects of a rural sociological character in relation to research studies. This report considers critically the type of sociological extension work being carried on and points out the necessity for a more thoroughgoing sociological selection of projects.

It is realized that no one has at any time underrated the importance of the population side of agriculture; but the complexity of the purely human phases of agricultural life has seemed to many economists to offer a well-nigh insuperable obstacle to precise investigation and research, thus rendering a scientific body of knowledge in this particular impracticable. The work of this division, however, has helped to convince economists and the public generally that the human-relationships factor in agriculture, especially in its larger collective respects, is amenable to scientific analysis and to illuminating interpretation.

SHIFTS IN FARM POPULATION

The 1928 survey of the movement of population to and from farms indicates that the farm population is still on the whole slightly declining in absolute numbers. The usual interpretation of this phenomenon is that the decrease is due largely, if not wholly, to the release of farm laborers to cities by reason of power farming. It should be noted, however, that increased mechanical efficiency has not only released labor, but that increased scientific management, reducing costs, has driven out the ineffective farm operator who, unable to adapt his practices to new ways of agriculture, could not meet costs and so left the occupation. The future seems to hold in store a régime of scientific farming. Those farmers who remain will either conform to science in their practice or drop to a low standard of living, eking out a small return from farming by labor in other directions as opportunity permits.

RURAL-POPULATION ANALYSIS

An analysis of the rural population of New York State from the year 1855 to 1925, made at Cornell University

in cooperation with this division, illustrates how research in the field of population statistics has definitely added to the body of farm-population knowledge. Precise knowledge on the decrease of farm population in counties of low density, increase of village population in certain periods of farmer prosperity, decrease at other periods, and increase of rural population in counties of high density—all throw light upon the economic problems of the farm and show the specific effects in the country districts of city growth out of country recruits.

STANDARDS OF LIVING

A study of standards of farm family living in Laurel County, Ky., one of the so-called mountain counties, shows a range of annual living expenditures among 203 families from $214 to $1,946, with an average of $689, which is considerably lower than the average living costs among over 3,000 families studied before in various States. The outstanding phenomenon in this study is that 35.5 per cent of the families received other income than that from farming. Local industries helped out farming in this county. An Ohio study made last year showed a similar fact. The characteristics of the farms in both studies are poor soil, difficult topography, small farms, little tillable land. A fair hypothesis is suggested by these studies—that 40 per cent of the farm population of the United States is living on farms of this general character, which limits the family at present to a low standard of living, even with outside sources of income amounting to a considerable sum. These studies of standards of living raise the question whether agriculture must not face a permanent condition of having a large percentage of part-time farmers, progress in whose living conditions must include a program of establishment of rural industries as well as a special type of farm management.

TOWN-COUNTRY RELATIONS

Cooperative studies of relationships between town and country have been undertaken in several States. These studies try to find out what types of services farmers' towns of various sizes can successfully render to their respective trade areas. They likewise seek a greater understanding of the farmers' trading habits and the relation of these to the social institutions and agencies with which they maintain contacts. The findings of such research projects also have a very real bearing upon rural organization for any purpose, economic or social, when effective local groups of farmers or farmers and townspeople are to be established.

PROBLEMS IN COOPERATIVE MARKETING

A study of 350 local farmer organizations in Wisconsin indicates that rural organizations pass through definite life cycles—stimulation, rise, carrying-on, decline. A period of crisis comes between the fourth and seventh years. Organizations concerned with business activities live longest. Success is measured in tasks achieved, not in years of life. Constant adaptation to new conditions is necessary to continued life, and life may be prolonged by timely adjustments. The difficulties of organizations circle about "lack of good leaders," "lack of good program making," "members losing interest," "trouble with other groups." Grappling constantly with these difficulties tends to lengthening the usefulness of organization, and extension help at these points seems much needed.

Studies of the social factors involved in the cooperative marketing of farm products have been made in cooperation with the Division of Cooperative Marketing. A study has been made of the problems connected with the cooperative marketing of potatoes by farmers in the Eastern Shore section of Maryland and Virginia. As a result, recommendations were issued with regard to proper relations between members and their associations. It was pointed out that accurate and adequate information on the part of the members and loyalty to the organization are fully as necessary to the success of a cooperative enterprise as the proper physical and economic conditions. Concrete suggestions were made for bringing about more active support of the organization by individual members and better dissemination of accurate information on the part of the management.

As a part of the bureau's special cotton-marketing study, this division undertook an investigation of cotton-marketing experiences and habits of farmers in North Carolina and Alabama. It was noted that where community life and social activities are strong and effective, cotton cooperation is strong and effective, and where community consciousness is weak and in-

dividualism on the part of the farmers is marked, cooperation itself is weak and difficult. The results of this study are being prepared for publication.

DIVISION OF LAND ECONOMICS

L. C. Gray, *in charge*

LAND RESOURCES AND LAND UTILIZATION

Causes of the agricultural surplus have been studied, particularly the use of the tractor and resultant geographic shifts in crop and livestock production, the increased production of meat and milk per unit of feed consumed by farm animals, changes in crop yields per acre, and trends in exports and imports and in the domestic consumption of farm products. These studies furnish a background for estimating the probable changes in need for farm land and provide a basis for indicating the proper direction of a land policy.

Two preliminary reports have been prepared. The first, entitled "Do We Need More Farm Land?" was published in an economic journal and was also issued by the bureau and distributed to teachers in agricultural colleges and to members of the extension service in the several States. The second paper, entitled "The Trend of Agricultural Production," was read at a conference on population held at the University of Chicago. Talks based on these investigations have been given at meetings of county agricultural agents, extension specialists, and agricultural economists, held at the Universities of Minnesota, Wisconsin, and Illinois, and at Purdue University.

Two other studies, carried out in greater detail, have resulted from the investigations. Regional Changes of Farm Animal Production in Relation to Land Utilization and Regional Changes in Crop Acreage and Production Since the World War in Relation to Land Utilization are being prepared for publication. These studies show the extraordinary geographic shifts in land utilization and agricultural production that have occurred since the World War. Apparently shifts from one crop to another and from one class of livestock to another have had more effect upon aggregate production than changes in total crop acreage or in crop yields per acre.

The index of agricultural production, which has involved two years of statistical work, is now practically completed. This index, which includes acreage, consumption, and production, provides basic data for studying changes in land utilization and the resultant effect on production and for determining the relationship of the trend of agricultural production to requirements for farm products. A report interpreting these data is in preparation.

A revised Graphic Summary of American Agriculture, consisting of over 300 maps and graphs, based on the 1925 census and later estimates, has been prepared. The Temperature, Sunshine, and Wind section of the Atlas of American Agriculture, prepared by the Weather Bureau with the aid of this division and under its general direction, has been published, and work on the soils section of the atlas has been continued.

LOCAL LAND UTILIZATION AND MARGINAL-LAND STUDIES

Large areas of marginal and submarginal land are in private ownership in many parts of the United States. The division has been engaged in a number of local studies of land utilization in various selected districts in such regions, in cooperation with the Forest Service and various experiment stations. The studies are directed specifically to problems arising in those marginal or submarginal districts where the land is already largely in farms and where the low productivity of the land is reflected in low incomes and low standards of living, farm abandonment, tax delinquency, inferior educational facilities, and poor roads.

A number of these studies have been carried on in the Appalachian area, notably in the mountains of Kentucky, and northern West Virginia. A new project has been started in Vermont. In this general region, agriculture, until recently, has been closely linked with forest industries, which have furnished employment and an outlet for surplus farm products, but the bulk of the merchantable timber has now been cut. On much of the land farming no longer pays, and many fields are being abandoned. The burden of carrying cut-over land is pressing heavily on the owners. The problem of future land utilization in the region is, therefore, of urgent interest both from the private and the public standpoint.

The studies have indicated their practical value as a basis for the development of State-owned forests through the differentiation of farm

from forest lands. They are useful in formulating agricultural extension programs. Extension workers will be able to give such advice as will eliminate a great deal of the friction incident to the transitional process from farming to other industries, and at the same time bring the transition about more quickly. On the basis of soil surveys, topographic maps, and miscellaneous data the results of such studies can be generalized to apply to much larger sections.

In certain submarginal districts extensive tax delinquency and farm abandonment have occurred, resulting in a rapid increase in the burden of local government. In cooperation with the United States Forest Service and the Wisconsin Agricultural Experiment Station, a study of taxation in relation to land utilization in certain districts of northern Wisconsin has been completed. The results of the study, published as Wisconsin Bulletin 406, show the need for land-use programs which aim to eliminate scattered settlement and assign land to its best uses. The many factors which must be taken into account in connection with a wiser land-use program are also presented in this bulletin. Largely as a result of this study, a suggested working plan for classifying land resources and formulating a land-utilization program for northern Wisconsin counties was prepared for use by county authorities and extension workers of the Wisconsin College of Agriculture.

LAND-SETTLEMENT STUDIES

The success or failure of agriculture in marginal areas is frequently dependent largely on methods employed in the sale and settlement of the land. The turnover of settlers in 46 settlements, representing various types of land-settlement projects in the cut-over region of the Great Lakes States, is being studied in cooperation with the experiment stations of Minnesota, Wisconsin, and Michigan, and with the Wisconsin Department of Agriculture.

A manuscript descriptive of the economic aspects of land settlement in the Great Lakes States (Wisconsin, Minnesota, and Michigan) has been nearly completed for publication as a farmers' bulletin. This manuscript presents graphically some of the fundamental conditions affecting the development of the cut-over region. It also describes the progress the average settler may expect to make in developing a farm on cut-over land.

With a view to establishing a widely recognized service on land-settlement questions, a special effort is being made to gain the cooperation of land-selling agencies, prospective settlers, and State and other public officials concerned with land-settlement activities. To satisfy the numerous requests for information concerning opportunities for settlement and methods of selling and settling land, 8,000 letters were mailed to public officials and land-selling agencies, requesting information relative to land for sale, prices asked, terms of purchase, how and where purchasers are solicited, etc. The response to these requests has been gratifying.

LAND APPRAISAL AND LAND VALUES

Results of the fourth annual survey of conditions in the farm real-estate market indicated that the decline in farm real-estate values had continued, but the decreases on the average were comparatively slight, amounting to about 1 per cent for the country as a whole. On March 1, 1929, the average value per acre of all farm lands with improvements stood at a point 16 per cent above 1912–1914 average regarded as the pre-war level, as compared with a position 70 per cent above that reached in 1920. The 1929 value levels varied considerably as between the various States, ranging from 60 per cent above the pre-war levels in California to 28 per cent below the pre-war levels in Montana. In some States, as in Montana for example, the decline appears to have reached an end, but in other States, as in Iowa, there was no assurance that the bottom had fully been reached. Although the survey showed that the rate of foreclosures and other defaults had on the whole declined somewhat for the 12 months to about 15 farms per 1,000 farms, the rate was still above normal in a number of States. Voluntary sales fell off somewhat during the period, and from the available evidence still remain much below normal.

These and other data indicative of trend and outlook in the farm-lands market were developed by the division to meet demands for authoritative information on the part of farmers, credit institutions, appraisers, and others closely concerned with the great changes which have taken place in the farm real-estate situation. A beginning only has been made in this work, and development must proceed appreciably further before demands for information in this comparatively new

field can be met adequately. This division participated in three short courses on land-valuation subjects conducted under the auspices of State agricultural experiment stations. The rapid development of this new type of educational activity in response to requests of individuals and agencies directly concerned with the practical problem emphasizes the increasing interest in the subject of land appraisal.

Continued progress was made on studies of various local factors influencing farm real-estate values. These investigations are being carried on in cooperation with the Bureau of Public Roads. Determination of the net effect upon farm value of buildings, roads, soils, etc., should aid in the development of improved land-appraisal methods and throw light on the problems of rural highway financing. An analysis of land values in the cut-over area of the Great Lake States, pursued cooperatively with the Minnesota Agricultural Experiment Station, is being prepared for publication.

LAND TENURE

Relationships between the tenure of farm land and various phases of agricultural production and marketing have been analyzed in a study of agricultural readjustment in the old plantation piedmont. This belt of 59 counties, mostly in South Carolina and Georgia, has been adversely affected by boll-weevil damage to cotton, drouth, low prices, and other unfavorable conditions since 1920. Much of the land was formerly operated by standing renters, and many of the holdings are large. It seems clear that the absentee owners have been less able to meet the situation than have owner operators. The family-size farm has withstood the shock better than the large plantation, although a few of the latter under capable management have adjusted their business to the changed conditions. A study of conditions of land tenure and their relation to income and financial progress of small white farmers in north Georgia has recently come from the press as Circular 78.

Analysis of the data made available by the 1925 census has been continued. Some of the material will be used in the Graphic Summary of American Agriculture, and some will probably be issued in a special publication which will deal with the relation of crop and livestock production to tenure. A special analysis of detailed information concerning farms 1,000 acres or more in area is almost completed. Assistance has been given to investigators carrying on studies in land tenure in Delaware, Kentucky, and Virginia.

RELATIONSHIP OF THE PUBLIC DOMAIN TO THE AGRICULTURAL RANGE INDUSTRY

Need for better-defined legal authority for the use of the public domain as grazing land has been recognized for several years, but lack of agreement among users as to the best method of obtaining it has prevented legislative action. Believing that these differences of opinion rest on definite regional differences in physical, economic, legal, and social conditions which have never been clearly defined and understood, steps were taken in 1927 to make detailed studies of representative districts. The State of Nevada, which contains about one-third of the remaining public domain, was selected as the special field of study.

This study is nearing completion. A map showing present ownership and type of utilization now practiced is finished. A map of the authorized use of water for irrigation and for stock-watering places has been prepared. The irrigable land shows the area which can be cropped and which now furnishes part of the winter feed for stock. The location of watering places indicates the distribution of the privately controlled stock water, on both private and public lands, and under State laws helps to establish the limits of the indefinite permissive control of the range lands now legally recognized.

A map of certain representative areas showing the privately owned lands of individual stockmen, their stock-water holdings, and the boundaries of the areas of associated public lands that they claim the right to use is now being prepared. This map will present graphically (1) the intermingling of interests sometimes common, sometimes competitive, due to the overlapping of claims, and (2) the need for better and more authoritative delimitation of the boundaries of use rights.

In connection with the study, a summary of the Federal and State legislation and various judicial decisions relative to the use of public lands and the control of waters in Nevada has been made. This summary not only shows what has been done but also indicates the need of further definitive action in order to improve the legal status of the range livestock industry.

FARM LABOR

In December, 1928, a questionnaire concerning the relative amounts of time spent on farm work by various classes of farm labor, family (paid and unpaid) and hired, and the amounts of wages paid each was sent to correspondents throughout the country, and tabulation of replies has been begun. Summarization of data received from an inquiry of a year earlier concerning monthly wage payments by farmers to various classes of labor has been practically completed.

A preliminary report entitled "The Perquisites and Wages of Hired Farm Hands" has been issued, giving the principal results of the study concerning money wages and payments in kind to noncasual and casual hired farm laborers. These studies reveal the large relative importance of perquisites as a method of paying farm wages and indicate the relative importance of different classes of perquisites. This makes possible more complete estimates of real, as distinguished from money, wages of farm laborers.

TOBACCO SECTION

CHARLES E. GAGE, *in charge*

To provide for duties which recent legislation has imposed on the Department of Agriculture, a new unit known as the Tobacco Section has been organized. This section will administer the tobacco stocks and standards act, approved January 14, 1929, providing for quarterly reports on the stocks of leaf tobacco in the hands of dealers and manufacturers, formerly issued by the Department of Commerce, and will inaugurate the tobacco-grading service provided for in the appropriation act for 1930.

Under the provisions of the tobacco stocks and standards act, the April 1 and July 1 tobacco-stocks reports show for the first time not only a complete separation according to type but a separation of new and old crops. Preliminary work has been accomplished in preparation for a further separation of stocks according to groups of grades, which will have the effect of disclosing the quantity of tobacco on hand according to its manufacturing utility. Sufficient progress has been made to indicate that reports on this basis can be undertaken in the near future. These reports will make available much more adequate statistics on tobacco than are now available.

Although the appropriation for tobacco grading did not become available until July 1, 1929, plans were formulated, and preparatory work was accomplished for the inauguration of this new service. Under the terms of cooperative agreements, negotiated with numerous tobacco-producing States, the nucleus of an organization has been created which will enable tobacco growers to know the grade of their product according to Federal standards before it is sold. It has been demonstrated that such services tend to improve and stabilize prices. Favorable comments have been received from the growers and the tobacco trade in regard to this new activity.

COLD-STORAGE STATISTICS

WILLIAM BROXTON, *in charge*

According to the latest summary of the cold-storage industry, there are 1,363 establishments engaged in storing food products under refrigeration. Practically all of these furnish information to this bureau; consequently it is believed that the reports on cold-storage holdings as issued represent close to 100 per cent of the total tonnage of such commodities stored throughout the United States. The reports cover fresh fruit, frozen and preserved fruits, dairy products, eggs, frozen poultry, meats, and meat products.

There is an active demand for data on cold-storage holdings, and several extensive special tabulations were prepared for producers' organizations and others. The slaughterhouse statistics compiled in this section have been in demand, especially in connection with the subject of direct marketing of livestock.

OPERATION OF CENTER MARKET

C. H. WALLEIGH, *superintendent*

The operation of Center Market, Washington, D. C., has been continued along lines laid down in previous years. Repairs and alterations have been held to the minimum in view of pending legislation to discontinue the market in order that the space may be used in carrying out the Federal building program. Only such repairs as were necessary for sanitation and efficient operation were made. Financial reports filed by all stand holders with the market show gross sales, volume of business handled, and expenses incurred in its conduct.

ECONOMIC LIBRARY

MARY G. LACY, *in charge*

A steady increase in the demand for the services of the library on the part of the public as well as from departmental workers marked the year's progress. An unusually large number of bibliographies were undertaken in response to definite and urgent requests. These bibliographies included such subjects as labor requirements of farm products; agricultural relief; population movements; large-scale and corporation farming; land valuation; agricultural credit; and numerous others. A member of the staff won the Eunice Rockwood Oberly Memorial prize for a bibliography entitled "Control of Production of Agricultural Products by Governments."

Additions to the library included 3,483 books and a net increase of 31 periodicals. A total of 1,759 periodicals is now received. In addition extensive files are maintained of current reports covering crop and market conditions and related subjects. Special files are kept of foreign material, including reports from the bureau's foreign representatives, consular reports, reports from foreign governments, etc. Approximately 19,000 reports are circulated annually, both within and without the bureau.

The library handles a large correspondence, which entails much reference and research work.

DIVISION OF ECONOMIC INFORMATION

J. CLYDE MARQUIS, *in charge*

The volume and variety of economic information continues to grow rapidly. The inauguration of new lines of service and research in the bureau has added to the information work. The expansion of the current work in crop estimates, market news, and research has brought many new types of information into the bureau which must be prepared in the form which will be of greatest service to those who need the facts.

One of the main tasks of the division has been to coordinate and systematize the publications of the bureau. The purpose is to bring economic information into certain definite groups of publications so as to make it most useful to extension workers and others. This has become necessary because of the extension of outlook work into practically every State, since this work calls for information classified by commodities and regions. The calls upon the bureau for information are reflected by constantly increasing correspondence, and the further fact that editions of publications are quickly exhausted. Facilities for printing and mimeographing have been taxed to the utmost.

PRINTED PUBLICATIONS

The printed bulletins of the bureau have had to be supplemented during the past year by an increased volume of multigraphing and mimeographing. The preparation of manuscripts for regular department printed publications has been limited to those which were most urgently needed in large quantity. The distribution of information has been increased in the form of multigraphs and mimeographs as much as the facilities of the bureau and department would permit. Every economy has been practiced that would facilitate securing more output with the same facilities, such as single-spacing copy, duplicating on both sides of the paper, and very close editing.

A comprehensive survey of the probable printing needs of the bureau during the next two years has been made and prospective manuscripts listed in order to present accurate estimates of the future needs in the form of printed publications. These estimates show that the bureau still has a large amount of material in the form of unanalyzed data which should be written into useful publications.

The regular periodicals of the bureau have been continued. No new periodicals have been started during the year, but the distribution of all those now issued continues to expand.

Of printed publications including bulletins, circulars, service announcements, etc., the output of the year was 46. Ninety-one preliminary and special reports were published in either multigraphed, mimeographed, or rotaprint form. This number is about three times the output of the previous year and has helped greatly in meeting the urgent demand for economic information.

PRESS DISTRIBUTION OF BUREAU FACTS

The press still remains the greatest single method of distributing this bureau's information, with a larger body of readers than ever before, due to increased circulation among newspapers and periodicals. Information for the current newspapers, farm, and

trade papers has been released in increasing volume. Through the department press service about 250 formal statements have been issued during the year. A large number of reports were given to the press association and local correspondents for special handling according to the needs of each publication. The press clipping service is inadequate to measure the amount of this copy that has been used, but it amounts to thousands of items annually.

Bureau information gets its widest distribution through the daily and weekly newspapers and these papers are served principally through the Washington offices of the news syndicates. A survey of the distribution of market reports issued by the Division of Livestock, Meats, and Wool showed that through the news syndicates a total of 682 newspapers were being reached, representing all parts of the country, the total circulation of which amounts to many millions daily or weekly.

Press distribution of information has been increased by the preparation of more special articles for farm journals and daily and weekly papers. Over 100 special articles have been written on bureau work for periodicals. Independent special writers have been furnished material which has appeared in many places.

Arrangements have been made with many of the papers to use the bureau's information in regular departments. These include some of the leading livestock papers, fruit-trade journals, and general farm papers.

RADIO NEWS SERVICE

The radio market news service has been expanded, and approximately 115 stations are cooperating with the bureau. The character of material broadcast has been improved. The joint program in cooperation with several of the New England State bureaus of markets has been continued. A joint program was begun in January in cooperation with the Alabama Division of Markets at Montgomery, the broadcasting being done through the station located at Birmingham through remote control. This addition made radio reports available to a large section heretofore somewhat removed from a station.

A new program of livestock reports was developed at Omaha. The Missouri State Department of Agriculture installed an additional operator on the leased wire so as to be able to use both livestock and fruit and vegetable information, thereby making the program from that station one of the most complete in the country.

Steps were taken toward closer cooperation in radio and market-news work in New York City. A joint operating committee on radio was appointed and duplication of broadcastings eliminated.

A plan for a national system of market broadcasting has been outlined and extensions during the year planned in accordance with this layout, the objective being to make both local and national markets available during both day and night periods to all farmers in the country.

As a part of the chain broadcasting program of the department, the bureau has contributed a large number of short talks during the year. The most important statements of the bureau on crop reports, outlook statements, the monthly price situation, etc., have been broadcast by bureau workers over the chains reaching about 40 stations. Economic talks have also been prepared for the department's syndicate radio service, which is furnished to more than 30 stations.

EXHIBITS AND FILMS

The exhibit section assisted in preparing material for one European exposition and five national shows in this country, which included the exposition at Seville, Spain, the National Dairy Exposition, the National Cotton Show, International Livestock Exposition, American Farm Bureau Exhibit, and the Chemical Industries Exposition.

The bureau display for the National Cotton Show constituted almost all of the department's contribution.

Supplementing the preparation of exhibits for large expositions, special displays have been prepared for several smaller shows. Small portfolios for use at farmer's meetings have been completed on a dozen lines of bureau work and are kept in constant circulation.

In cooperation with the visual education section of the Extension Service, a number of film-strip lectures have been prepared for extension workers. Over 20 different subjects are now in preparation.

During the year four new motion pictures have been completed. One depicted the master-farmer movement in Oklahoma and was prepared in cooperation with Oklahoma agencies.

Another showed the use of the new combine harvester. A film was made on lamb-cutting demonstrations, in cooperation with the National Livestock and Meat Board. One showed the cooperative marketing of livestock.

AIDS FOR ECONOMIC EXTENSION

A number of special publications to aid extension workers in presenting the Outlook Report were developed. Collections of charts were issued and distributed to all State outlook workers. Two handbooks, one on livestock and one on crops, were prepared, each containing over 100 of the most significant charts.

Enlarged wall charts, prepared by the photographic laboratory upon bromide paper, were furnished to extension workers in each State. To introduce the charts, 35 on different subjects were furnished free to each State, and then orders for additional charts were filled at a small charge for the cost of preparation. Over 2,500 copies of these charts were distributed following the outlook conference in January. They have been universally approved and have been a large factor in the extension of the outlook information. The revision of these charts for use in connection with later outlook reports has been continued, and they will be issued in handbook form for use with later reports.

The director of economic information has attended several meetings of teachers of agriculture in high schools and described the material which the bureau has available for teaching agricultural economics. The result has been shown in calls from these teachers and the adoption of outlook work as a regular part of the course of study by some of these schools.

LEGISLATIVE SERVICE

The agricultural legislative service, begun last year at the suggestion of the National Association of Marketing Officials, has proved its usefulness. Through this service a constant record is made available to agricultural leaders of congressional action on bills relating to marketing or the department or bureaus, as well as a review of cases in the courts relating to marketing and other subjects of interest to marketing specialists and others. A valuable file of information on agricultural legislation is being accumulated, and various offices are making more and more use of the service.

U. S. GOVERNMENT PRINTING OFFICE: 1923

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REPORT OF THE CHIEF OF THE BUREAU OF ANIMAL INDUSTRY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., August 24, 1929.

SIR: I have the honor to transmit herewith a report of the operations of the Bureau of Animal Industry for the fiscal year ended June 30, 1929.

Respectfully,

JOHN R. MOHLER,
Chief of Bureau.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

ACTIVITIES OF NOTEWORTHY PROMINENCE

The work of the Bureau of Animal Industry during the last year dealt, as previously, with a wide range of experimental projects, research studies, enforcement of Federal livestock laws, inspection duties, and the eradication and control of animal diseases, largely in cooperation with the States. The results of completed experimental and research work are available to the public in bulletins or in the Journal of Agricultural Research. A record of the bureau's principal activities in administering Federal statutes appears in the Service and Regulatory Announcements, issued monthly. This report deals chiefly with subjects of special interest to the public as well as providing record of the principal results of bureau work during the year.

TUBERCULOSIS OF CATTLE AND HOGS DECLINES

The effectiveness of the cooperative campaign to eradicate tuberculosis from livestock is definitely shown by records of the Federal meat-inspection service. During the year a gratifying decline occurred in the number of cattle and swine carcasses and parts condemned on post-mortem examination because of that disease. For several years a slight decrease had been noted, but the downward trend is now very pronounced.

In the case of cattle, the number of carcasses condemned for tuberculosis, per million cattle slaughtered, declined from 430 in 1928 to 380 in 1929. During the same period the corresponding number of parts condemned declined from 660 to 530. In the case of swine, carcass condemnations per million animals declined from 1,150 in 1928 to 990 in 1929. Swine parts condemned per million hogs slaughtered during the same period declined from 1,070 to 850. These distinct downward trends in diseased carcasses and parts signify not only the saving of large quantities of meat, but also less tuberculosis among cattle and swine in the producing areas. Although surveys in connection with tuberculosis-eradication work have indicated a reduced prevalence of the disease, the actual post-mortem examination of cattle and swine entering the commercial meat supply is indisputable evidence.

INCREASE IN IMPORT MEATS

Records of Federal meat-inspection service, besides acting as an index to the prevalence of animal maladies, likewise show noteworthy trends in import and export trade in meats. During the year a material increase in meat imports occurred. Those of cured and canned meats were more than 26,000,000 pounds greater than during the previous year, most of the increase being represented by canned product.

Imports of fresh beef likewise showed an increase amounting to approximately 16,000,000 pounds. These increases in receipts are apparently largely the result of an attractive price level in the United States. Since this country has not imported meat to any material extent in recent years, the increase in receipts is noteworthy.

OUTBREAK OF FOOT-AND-MOUTH DISEASE QUICKLY SUPPRESSED

During the year the United States suffered its ninth invasion of foot-and mouth disease, which fortunately was promptly discovered and within 60 days was entirely eradicated. The infection appeared in a large herd of garbage-fed swine in Los Angeles County, Calif. With commendable promptness the owner reported the strange malady to a county veterinary inspector, who visited the herd at once and took the necessary steps to limit the spread of the infection. The eradication measures were conducted jointly by Federal, State, and county officials with the result that the spread of this highly infectious disease was restricted to five herds in the vicinity of the first premises infected.

The method of eradication consisted in the slaughter and burial of all affected or exposed livestock, together with strict quarantine regulations and the disinfection of premises and equipment. Investigation showed that the infection had been introduced into the United States through infected fresh meat in the form of garbage from a merchant vessel that had recently made a South American cruise. It is noteworthy that the foot-and-mouth-disease outbreaks of 1914 and 1924 also were traced to infected meat from countries where foot-and-mouth disease exists.

This experience, in connection with findings of the British foot-and-mouth-disease research committee and of the American commission which studied the same disease, shows the serious danger of infection through imported fresh meat from countries where foot-and-mouth disease exists.

Although regulations and quarantine restrictions have been materially strengthened in recent years, there is constant danger of introducing foot-and-mouth disease into the United States, owing to its great volume of imports. Accordingly, the bureau maintains at convenient points throughout the country equipment and supplies used in combating foot-and-mouth disease. The bureau's personnel also includes men trained in diagnosing this disease and conducting field operations with the necessary energy and dispatch. Although occasional outbreaks may occur at times, experience has shown that foot-and-mouth disease can be eradicated promptly and without serious economic loss if the disease is reported promptly and eradication work is conducted with whole-hearted cooperation on the part of livestock owners and public officials.

SMALL OUTBREAK OF EUROPEAN FOWL PEST

Another foreign livestock disease, European fowl pest, appeared in the United States about the middle of June, 1929. The outbreak occurred in Morris County, N. J., but was restricted to four infected and four exposed premises through vigorous measures conducted jointly by New Jersey veterinary officials, the agricultural experiment station of that State, and the bureau. Eradication methods consisted in the burning of diseased and exposed birds, thorough disinfection of premises, and a second disinfection of laying and brooder houses. State and Federal veterinary inspectors at New York City, Jersey City, Paterson, and Newark made close observations at those market centers for signs of the disease among poultry shipments but found none, indicating that the eradication work had been effective. The outbreak was the second time that European fowl pest has invaded the United States. Owing to the small number of infected premises the invasion of this pest was suppressed in two weeks and was without economic significance.

INFECTIOUS ABORTION

The investigation of infectious abortion has continued to receive special attention by the bureau's investigators in view of the great need for improved means of combating this costly disease. The experimental work has included: Attempts to develop effective methods of artificial immunization, including calfhood immunization; comparative studies of the abortion organism of the type found in both cattle and swine; the study of the eye as a route of infection; and the dependability of the agglutination test as a means of designating the presence of infection.

The results of these and related studies have added materially to technical knowledge concerning infectious

abortion, but do not yet justify any change in the practical recommendations for combating the disease, as outlined in the department's Farmers' Bulletin on the subject.

FURTHER PROGRESS IN TICK ERADICATION

The eradication of cattle ticks from Southern States continues to proceed steadily. The Atlantic seaboard States north of Florida have now all been released from quarantine because of cattle ticks and particular interest now centers in the active campaign against ticks in the State mentioned. Success already achieved in freeing the northern counties of Florida from this destructive parasite foreshadows a rapid increase in the tick-free area of the State. Oklahoma became free from Federal quarantine during the year, being the ninth State of the 15 originally infected to achieve that goal.

Public opinion in support of tick eradication is being greatly strengthened by the development of profitable beef and dairy herds in localities already freed of ticks. As in the past, the exact territory subject to Federal quarantine because of this parasite is determined late in the calendar year on the basis of final dipping reports for the season.

STOCKYARDS WORK CONSOLIDATED

In order to consolidate the closely related activities in one division, supervision over livestock moving interstate, including the enforcement of the 28-hour law, was transferred at the beginning of the fiscal year from the Field Inspection Division to the Packers and Stockyards Division. The realignment of work has increased the scope of the Packers and Stockyards Division, which now administers not only the packers and stockyards act but also the laws and regulations governing the interstate movement of livestock and related inspection work at public stockyards.

ENFORCEMENT OF PACKERS AND STOCKYARDS ACT

In enforcing the packers and stockyards act the bureau has endeavored to dispose of formal dockets as promptly as possible. The number of dockets pending at the end of the fiscal year was 14, as compared with 18 at the beginning of the year. During the 12-month intervening period 16 dockets were instituted, and final action was taken on 20.

Several important court decisions—one involving boycott of a cooperative agency and another the authority of the Secretary to fix rates—were rendered, the general effect of which was to support the Secretary in the authority vested in him by the act.

CONTROL OF HOG CHOLERA

The extensive use of the preventive-serum treatment is keeping hog cholera under reasonably effective control. Outbreaks of the disease are the result usually of failure on the part of swine growers to administer the treatment in time, to maintain proper sanitation, or to use precautions which help to keep infection from their premises. The number of outbreaks reported from all sources was approximately 7,000, which is a slight increase over the corresponding number for 1928 but about 4,000 less than in 1927.

In addition to its former field activities for combating hog cholera through investigation, demonstrations, autopsies, and educational means, the bureau adopted a new plan in cooperation with nine Southern States. The method involved the selection of a limited area within a State, which serves to demonstrate the value of immunization and the use of sanitary measures in swine production. The plan includes the prevention and control of swine diseases and parasites by proper treatment and management.

SUPERVISION OF BIOLOGICAL PRODUCTS

In the administrative and regulatory work conducted under the virus-serum-toxin act a noteworthy development is the steady increase in the manufacture of clear anti-hog-cholera serum compared with defibrinated-blood serum. During the fiscal year 1928 the production of the clear product exceeded that of the other for the first time. During the year just closed the quantity of clear serum produced was about three times that of defibrinated-blood serum, indicating that public preference for the clarified product has continued to develop very rapidly. Although both kinds of serum are effective in preventing hog cholera, the preference for the more refined product shows that swine owners and veterinarians are keenly discriminating in this detail of hog-cholera prevention and control. In fact, the size of the industry now engaged in producing veterinary biological products shows that livestock owners of the

United States are well informed regarding the properties and use of biologics in combating animal diseases which may be prevented or controlled by such means. Supervision over licensed establishments making these products showed a general compliance with the law and regulations, violations being usually of minor character.

ANIMAL-HUSBANDRY INVESTIGATIONS

In the field of animal husbandry the bureau has conducted a wide range of investigations on all the principal classes of livestock, including meats and other products derived from such animals. In order to make the studies as comprehensive as possible, they are conducted to a large degree in cooperation with State agricultural experiment stations and various other scientific organizations.

In the past, feeding trials with food animals have consisted largely in determining the gains, cost of gain, and prices received for animals when marketed. Such general results have not supplied the detailed information which livestock producers and the meat trade now seek. Hence, present studies deal specifically with the breeding, age, sex, and other characteristics of live animals and with the quality and palatability of their meat.

Recent results of such work indicate the desirability of marketing steers of inferior breeding while relatively young, preferably under 14 months of age. At that age the meat of such steers is reasonably satisfactory from the consumer's standpoint, whereas it would be much less desirable at a greater age. On the other hand, cattle of good quality can be grown out for a year or two and then fattened with the assurance that the meat will be choice. These meat studies with experimental cattle, swine, and sheep involved the examination of the carcasses of more than 2,000 animals in the meat laboratory during the year.

A determination of the most profitable rations for fattening livestock in different sections of the country continues to be an important part of the investigational work. It is obviously difficult for livestock owners to make accurate, comparative tests of the growth-producing and fattening qualities of available feeds, and the demand for such information has resulted in feeding experiments extending for several years in some cases. In fattening beef steers results in West Virginia have shown that although grass is the cheapest feed the greatest profits are derived when steers fattened on grass likewise receive a supplement, such as corn and cottonseed meal.

The length of fattening period likewise has been studied. In a test conducted in Louisiana a fattening period of 140 days, while sufficiently long for heifers, appeared to be too short for steers. On slaughter, the heifers were fatter and had higher dressing percentages than the steers, though the steers were more profitable by reason of a more economical use of feed. Such details in livestock feeding are now being obtained for the principal producing regions of the country and should enable livestock feeders to conduct their operations in a more profitable manner.

The size of calf crops in the range areas has received considerable study. Contagious abortion is a very common cause of low calf crops, and in the northern Great Plains region it is reported to be one of the most important factors. Liberal feeding of grain to condition bulls for the breeding season appears to be beneficial. Studies of ranch operations indicate the extreme importance of constantly observing the condition of the range in order to prevent overstocking and overgrazing.

Studies in wool and other fibers conducted at several bureau stations and in cooperation with States have yielded highly interesting and significant results. The study of wool growth shows that this fiber grows least in winter and most rapidly during the summer and fall months. The growth of mohair is in accordance with the same habit. Apparently the chief factors that influence the production and quality of wool are feed, weather, breeding, and individuality. Investigations in this field show also the importance of good management, since serious interference with the health and vigor of sheep may affect the quality of the wool. Carefully conducted scientific tests are disproving some incorrect beliefs which have become legendary among livestock producers. For instance, the palatability of meat from Rambouillet lambs, which are primarily a wool breed, has proved to compare favorably with that from lambs of the strictly mutton breeds.

The searching inquiry which the bureau, in cooperation with the States, has been making of the firmness of pork was continued during the year. The work centered largely on tests of different varieties of soybeans when

fed with corn and minerals. The wide variation in results obtained is typical of the difficulty in obtaining clear-cut results on which to base definite recommendations for feeding to prevent objectionable softness in pork. Experiments in feeding ground corn and ground soybeans, however, have shown that when at least 9 parts of corn for each part of soybeans are fed with minerals in a dry lot to pigs with initial weights of 100 pounds or more making good daily gains, a firm carcass usually is obtained.

Investigations with poultry have dealt principally with the factors affecting the fertility and hatchability of eggs and with the effect of feeding on egg yield. Since a long molting period is known to reduce the number of eggs laid by hens and pullets, a study has been made of factors affecting the molt. Results thus far indicate that feeding a mixture of inorganic sulphur compounds materially increases annual egg production, sulphur being an important constituent of feathers.

LIVESTOCK IMPROVEMENT

As in former years, the bureau continued to emphasize the importance of breeding improved types of livestock because of their superior utility value. The use of purebred sires has received particular emphasis. Extension workers and other leaders in livestock-improvement work were furnished large numbers of posters and other literature on the subject. The number of scrub-sire trials staged in accordance with the bureau's outline for conducting them showed a noteworthy increase over previous years. The number of livestock owners participating in the campaign for the use of purebred sires also increased to a total of 17,345 at the end of the year.

Taylor County, Ky., succeeded in eradicating all grade and scrub bulls, being the fourth county to achieve this distinction. A summary of data obtained in a world survey of livestock improvement indicated that most of the important livestock countries are actively endeavoring to increase the quality of their domestic animals.

VETERINARY EDUCATION

The activities and student enrollment of the accredited veterinary colleges during the school year 1928–29 continued to show encouraging growth. The number of graduates at the 1929 commencements was 141, an increase of 5 over the previous year. Registration of freshmen during the school year was 330, an increase of 88 over the attendance of 1927–28. The sophomore and junior classes also showed noteworthy increases.

The number of accredited veterinary colleges remains at 12, the same as the previous year, the entire number being under the supervision of the States in which they are located. The foreign recognized veterinary institutions are 10 in number, no change having occurred during the year.

PERSONNEL

The bureau rolls at the beginning of the fiscal year carried 4,171 employees of all grades and designations in Washington and on the field forces. Employees added to the rolls during the fiscal year were 693, as follows: 603 by appointment or reappointment, 72 by transfer from other bureaus or departments, and 18 by reinstatement. During the same period 121 employees resigned, 34 appointments were terminated on account of death, 15 were transferred to other bureaus or departments, 1 was removed for cause, and 30 were retired under the amended retirement act of July 3, 1926. Other separations, principally of agents, unskilled laborers, and seasonal and temporary employees, numbered 411, making the total for the fiscal year 612. The bureau rolls at the close of June 30, 1929, carried 4,252 employees, an increase of 81 over the number at the beginning of the year. This increase was caused principally by increased work on the bureau's experiment farms and consists almost entirely of unskilled laborers and other unclassified employees.

PUBLICATIONS, RADIO, EXHIBITS, AND MOTION PICTURES

Publications prepared by the bureau during the year included 146 new and revised documents. Contributions to the various series of publications included 65 farmers' bulletins, 7 technical bulletins, 5 leaflets, 7 contributions to the Journal of Agricultural Research, 8 orders of regulatory character, 32 Yearbook articles, 9 publications of miscellaneous nature, and 13 Service and Regulatory Announcements, including the index. The bureau furnished to the press service of the department approximately 135

timely articles dealing with topics of public interest. In addition, employees of the bureau contributed 88 manuscripts on various phases of livestock work to technical and agricultural periodicals.

In connection with the department's radio service, bureau specialists furnished a large quantity of information to be used as a basis for livestock and poultry programs, and likewise participated personally in the department's broadcasts over a network of stations.

Cooperating with the department's office of exhibits, the bureau furnished subject-matter material for 8 new exhibits and for the revision of 14 former ones for showing at State fairs, expositions, and similar use. In addition, 1 new exhibit was prepared and 5 others revised. Activities in this field likewise included the preparation of maps, charts, and lantern slides for special meetings and general educational use.

The bureau has continued to cooperate with the department's office of motion pictures in preparing scenarios and in making or revising motion pictures from a subject-matter standpoint.

The year's work as conducted by the various divisions is presented more fully in the following pages.

ANIMAL HUSBANDRY DIVISION

The work of the animal husbandry division, consisting chiefly of research in animal husbandry, including poultry husbandry, was conducted under the direction of E. W. Sheets, chief.

ANIMAL GENETICS

In swine-inbreeding investigations there was farrowed during the year a total of 7 first-generation, 91 second-generation, 17 third-generation, and 5 fourth-generation pigs from continuous brother-sister mating. Mortality has been much lower and growth has been more rapid among the inbred pigs this year than in any year since the experiment was started. As a result of the year's work two inbred lines are now rather firmly established and two new lines are in process of development.

The inbred families of guinea pigs, which have been maintained for many years and have now reached the twenty-ninth generation of continuous brother-sister mating, were continued. All the available surplus stock produced during the year has been used in special nutrition and histological research for which animals of known breeding and minimum variation are required.

In an experiment to determine the effect of age at first breeding on the subsequent fecundity of the dam and the vigor of the young, the results show that there is no apparent effect on either size or frequency of litters. However, the young from guinea pigs which were not bred until 500 days of age were much smaller at birth, had a much greater mortality between birth and weaning, and made much slower gains than did young from mothers which were first mated at 33 days.

ANIMAL NUTRITION

In studies of animal nutrition, comparisons were made between the composition of the carcass and some or all of the commercial cuts from various animals. A close relation was found between the fatness of the loin, ham, and whole carcass. Such data permit the estimation of the composition of hams from an analysis of the loin which, in turn, permits experimental work on hams without the necessity of utilizing one of the hams for analysis. In the case of chickens, analyses of the breast, leg, and remaining edible portion have shown that the fatness of the whole bird can not be estimated from an analysis of either the leg or the breast.

Studies of the influence of the kind of fat in feed on the fat in hogs were continued. It was found that the proportion of soybeans in the ration and consequently the percentage of oil are reflected in the composition of the lard.

The hatchability and growth of chick embryos have been studied in respiration calorimeters. Determinations were made of the effect of changes in temperature, relative humidity, concentration of carbon dioxide, and oxygen in the surrounding air. The results are being prepared for publication.

Studies of the effect of rations deficient in calcium or phosphorus on the development of the skeleton and teeth of swine have been continued in cooperation with Johns Hopkins University and the American Dental Association. The work has resulted in evidence of the malformation of teeth, caused by both a high-calcium and low-phosphorus ration and a high-phosphorus and low-calcium ration.

COOPERATIVE EXTENSION

Greater efficiency in production practices and a wider spread of knowledge concerning what the market wants and when it is wanted were the keynotes of the animal-husbandry extension activities of the year.

As in the past, the animal husbandry division has cooperated with Federal and State extension workers in the establishment and continuance of projects dealing with fundamental livestock problems. Among important developments during the year were an increase in the number of farms adopting improved practices in livestock production, more farmers feeding better-balanced rations, more boys and girls completing livestock club projects, and more animals involved in junior club work. Other livestock extension work centered about the increased use of purebred sires, practices of selection and culling, and improvement in livestock sanitation with special reference to control of diseases and parasites.

In extension work with swine the number of official ton litters reported as produced during the year was 492, distributed among 30 States. This was a smaller number than in the previous year. The decline is explained by the popularity of the so-called pig-crop project, which requires the inclusion of all brood sows on an individual farm. Ten of the States, principally in the Corn Belt, are conducting such work as a substitute for ton-litter clubs, or as a desirable companion or follow-up project for them.

Few organized projects were carried on with horses. The demonstration of the "bucking back" and "tying in" system of multiple hitches by which larger numbers of animals are worked by one driver with a single pair of lines was the most general activity. In addition, several States were active with colt, stallion, and gelding clubs and with demonstrations of the dynamometer, the standard method of measuring the pulling power of animals.

Poultry extension work was carried on in all the States by county agents and 88 subject-matter specialists. The outstanding problem was the more efficient raising of young stock, especially through the "grow healthy chick" campaigns which have been reported from 10 States enrolling 2,300,000 chicks. In Missouri a survey from 33 farms which followed "grow healthy chick" methods showed an increased return of 80 cents per bird, compared with ordinary methods.

MEAT INVESTIGATIONS

Four years have elapsed since the inauguration of an organized effort to compare accurately the variations in the characteristics of meat and to study the production, storage, and other factors concerned. It was necessary first to develop methods and to standardize procedure so that the meat could be studied comparably in several laboratories. Although many of the methods now in use are open to improvement, the results have been consistent.

Heretofore animal-husbandry feeding trials have been judged on the basis of gain, cost of gain, and selling price. The first two record the economic efficiency of the methods used. Selling price has been the only means by which investigators measured the character of the product. The tests, analyses, and comparisons in these meat investigations have been designed to separate and compare the various characteristics of amount and quality that the market considers under the one term "value"; to break up existing generalities into cause and effect. They also aim to eliminate the variable of personal opinion, always present in a commercial appraisal.

Nineteen State experiment stations, the Institute of American Meat Packers, and the National Live Stock and Meat Board cooperated in this line of research. In most instances the State stations have handled the production end of the experiment, standard meat samples from the resulting carcasses being consigned to the bureau's laboratory for technical study. The feeding trials have dealt largely with beef and lamb, though a beginning has been made with pork. They cover a wide range of production problems, including such factors as breeding, type, age, sex, fatness, and ration. In planning these projects effort was made to standardize feed-lot conditions so that a single factor, such as sex or breed, could be similarly compared by several stations.

For example, a comparison was made of beef from calves of improved and unimproved breeding. Forty pairs of ribs were sent to the laboratory from feeding trials conducted at two substations. Although the market grade of the purebred cattle ranked as high as "top good," and that of

the plain steers as low as "top common," there was no marked difference in the palatability of the meat from these respective lots. In fact, in several cases the rib roasts from the common calves were more tender than those of the grades and purebreds. It was noticed that the standard 10-day-aging period between the time of slaughter and the palatability tests produced a greater softening in the meat from the poorly bred animals than it did in that of the purebreds.

Probably no other data that have resulted thus far from meat investigations have a more direct and practical application than these comparisons between purebred and scrub steers. All the cattle were young, averaging from about 12 to 14 months of age. A livestock breeder desiring to grade up an existing herd of common cattle to the point where he may enjoy the increased profits of improved stock will normally produce a number of rather low-grade calves. An appreciation of the tenderness and general eating qualities of the beef of these young, plain cattle indicates a system of management that will send the commoner ones to market at an age when their beef, though rather lean and unattractive, can be used readily and satisfactorily by the consumer trade.

Seventy-eight pairs of ribs were used in a study of the differences between steer and heifer beef. The market grade of these cattle ranged from an average of choice in the consignment from one State to medium in the samples shipped in from another. This is a large cross section, yet the comparison of steer and heifer meat as to composition, tenderness, and general palatability developed the same relative ranking in each test.

Twelve head of cattle from the Ohio station were used in a comparison of the meat from calves and yearlings. Sixty-two carcasses from feeding trials of the West Virginia, Virginia, and Louisiana stations furnished a comparison of grain-and-grass feeding with that of grass alone. Other experiments compared the effect, on the meat, of cottonseed hulls and silage, cottonseed meal and soybean meal, linseed meal and cottonseed meal, and barley and corn. The effects of several kinds of hays and fodders have also been compared.

During the last three years meat investigations dealing with lamb have included detailed tests of yield, grade, fat, tenderness, and palatability, 817 lambs of various breeding being used.

The data from the experiments conducted in cooperation with State experiment stations will be published when jointly approved.

During the year the meat laboratory handled 2,154 experimental hogs, lambs, and cattle. A total of $38,321.04 was received from the sale of surplus and salvaged experimental meat. Of this sum $25,892.30 was returned to the State stations and $12,428.74 turned into the Treasury from the sale of Government-owned products.

BEEF-CATTLE INVESTIGATIONS

Research in beef production has been conducted during the year in the Appalachian region, the Corn Belt, the coastal plain, the sugarcane belt, and the western range areas.

BEEF-CATTLE RESEARCH IN EASTERN UNITED STATES

In accordance with a cooperative project with the West Virginia Agricultural Experiment Station, three experiments were conducted at Lewisburg, W. Va., to compare grass alone and grass supplemented with corn and cottonseed meal for fattening both medium and good lots of steers. The steers of both grades fed grain on grass gained 39 per cent more, and were 22 per cent more profitable than the steers fattened on grass alone.

A beef-cattle barn has been under construction during the year at the Animal Husbandry Experiment Farm, Beltsville, Md., which will provide space for handling a breeding herd of beef cattle, for the individual feeding of 30 steers, and for the milking of 18 Milking Shorthorn cows. This herd of Milking Shorthorns is kept for the purpose of studying the inheritance of beefiness and milking qualities in Shorthorns and financial returns yielded by such cattle. Owing to lack of facilities for conducting beef-cattle research properly, the investigations during the year were confined to the management of the beef herd under the most practical conditions.

Milking Shorthorns are also being developed at the Morgan Horse Farm, Middlebury, Vt. Because of the small number of cattle, efforts have been confined to breeding and individual-production costs. During the 12-month period ended April 30, 1928, one of the Shorthorn cows made an unoffi-

cial record of 13,912.4 pounds of milk, with 602.4 pounds of butterfat.

In cooperation with the Bureau of Agricultural Economics and the State agricultural experiment stations of Virginia and West Virginia, in November, 1928, the bureau completed a field reconnaissance in the mountainous regions of those States to determine the most practical method of production and systems of farming in those regions. Except in situations where the pasture grass has outstanding fattening properties, it appears that the rough grazing sections yield greater returns when used either for the production of young stock or for cattle to be sold as feeders than they will when the production of fat steers is attempted with insufficient winter feed and pastures which are unsuited for fattening.

BEEF-CATTLE RESEARCH IN THE CORN BELT

The first year's experiment of a new cooperative project with the University of Missouri, conducted at Sni-a-Bar Farms, Grain Valley, Mo., to compare corn alone, corn and cottonseed meal, and corn and oats as grain rations for fattening calves previously to weaning, has been completed. Three lots of calves, when 3 months of age, were started on these supplemental feeds, being fed in creeps while on pasture with their dams and weaned at about 8 months of age. There were no marked differences in the gains made by the three lots. In the 196-day feeding period in dry lot after they were weaned the corn-and-cottonseed-meal calves made the largest gains and had the highest finish. The corn-and-oats lot ranked second in gains and the corn lot last. The corn lot made the cheapest gain and returned as much profit as either of the other two at the prices of feeds used. The advantages of the addition of cottonseed meal was in the more rapid gains, somewhat better finish, and higher selling price.

BEEF-CATTLE RESEARCH IN THE SOUTH

At the Coastal Plain Experiment Station, McNeill, Miss., the sixth year of the project comparing burned cut-over pasture with unburned in its relation to beef production and reforestation of pines has been completed. While the beef cattle have made the greatest gains during the grazing season on the burned pasture, observations indicate that the loss of organic matter destroyed by fire, the severe erosion which results when the ground is left bare by fire, the damage to seedling pines, older trees, and the risk to fences and buildings offset by far the greater gains made by the cattle. A heavier rate of grazing is being tried to see whether the forage can be grazed off so closely that there will be no excuse for burning to remove the dead grass or "rough" which when left from the previous season prevents the cattle from grazing the young and tender grass in the spring. The young and tender grass is much more nutritious and would be produced and consumed in much larger quantities than the tough and wiry grass which is available when the new growth has grown above the "rough" or dead grass of the previous year or years.

At the Iberia Livestock Experiment Farm, Jeanerette, La., in fattening three lots of yearling steers on the same grain mixture of 5 parts of brewers' rice and 1 part cottonseed meal, and different roughages, it was found that hay alone and hay combined with silage produced greater gains and better finish when fed with brewers' rice and cottonseed meal in fattening steer rations, than silage by itself. The silage in each case was made of about 30 per cent soybeans and 70 per cent sorgo. These results agree with a similar experiment of the preceding year.

At the same station steer calves of one-fourth Brahman and three-fourths Hereford breeding made a poorer showing in the feed lot during a 140-day fattening period than steer calves of half Brahman and half Hereford breeding. This is the reverse of results obtained during the previous year. The inconclusiveness of these results is in keeping with other experiments, which indicated that there was little difference between the feed-lot performance of non-Brahman and half-Brahman cattle.

BEEF-CATTLE RESEARCH IN WESTERN RANGE AREAS

At the Range Livestock Experiment Station, Miles City, Mont., three rations of 14 pounds of alfalfa hay, alone, 14 pounds of alfalfa and three-fourths of a pound of cottonseed meal, and 10 pounds of alfalfa and 10 pounds of corn silage were satisfactory for wintering calves. The additional expense

for cottonseed meal was not justified by the somewhat larger gain over that on alfalfa alone.

The yearling steers and heifers were put in feed lots when range conditions due to cold weather and deep snow became adverse and weight losses were in evidence. While a ration of 24 pounds of alfalfa produced twice as much gain when fed to the steers as 12 pounds of alfalfa and 12 pounds of oat straw, the cost was enough more to offset the advantage of the additional gain. One lot of heifers received an average ration of 25 pounds of alfalfa hay whereas the other lot received 21 pounds of bluejoint hay. Either alfalfa hay or bluejoint hay is satisfactory for wintering yearling heifers so far as winter gains are concerned.

When a cow in the breeding herd showed signs of weakness she was brought in and fed. Approximately 55 per cent of the cows were maintained all winter in vigorous condition on the range with 22 pounds of cottonseed cake per head. The other 45 per cent were each fed 69 pounds of cottonseed cake, 767 pounds of alfalfa hay, 402 pounds of barley hay, and 1,170 pounds of oat straw, in about 62 days.

At the Ardmore Field Station, Ardmore, S. Dak., two lots of yearling steers were wintered respectively on 8 pounds of alfalfa hay and 4 pounds of oat straw, and 16 pounds of corn silage and 4 pounds of oat straw, with similar results. Therefore, it seems from the one year's test that 2 pounds of good corn silage when fed with straw is equal to 1 pound of alfalfa hay for wintering yearling steers.

Investigations carried on cooperatively with the Montana Agricultural Experiment Station at the north Montana substation, Havre, consisted in the wintering of beef cows and heifers and the fattening of calves. Five lots of 1,100-pound cows fed for 114 days made average gains per cow of 11, 35, 41, 83, and 62 pounds respectively on the following rations: Alfalfa hay, 20 pounds; oat hay, 17 pounds; sweetclover, 17 pounds; corn fodder, 21 pounds; and bluejoint hay, 19 pounds. The average of two years' results indicates that oat hay is superior to alfalfa, sweetclover, and bluejoint, these last three being about equal as roughages for wintering cows. Corn fodder was somewhat inferior to the other roughages, as about 50 per cent more of it was required to obtain slightly greater gains.

Heifers, weighing 740 pounds, wintered on 5 pounds of alfalfa hay and all the good oat, wheat, and barley straw they would eat (12 pounds) for 114 days did nearly as well as the heifers wintered on 19 pounds of alfalfa and the cost was less than half.

Heifer calves, weighing 400 pounds, wintered on 12 pounds of alfalfa daily for 146 days, made over three times as much gain (110 pounds) as the heifers wintered on 5 pounds of alfalfa and 5 pounds of oat straw and barley straw (32 pounds gain), but the cost of wintering was nearly doubled in the case of the lot receiving hay alone. The deciding factor in determining the value of these two rations will be known when the heifers are grown out and become producers in the breeding herd.

Analysis of the three years' records, 1925–1928, of the northern Great Plains cattle-ranch study comprising detailed records on 60 ranches strongly indicates that the unbalanced and unstable organization of most of the ranches is an important cause of the wide variations in net incomes. Failure to provide sufficient winter feed usually results in death losses that can not be offset by the saving from cheap wintering.

The comparison of ranch records with respect to methods of cattle management reveals that many factors may influence the calf crop. Contagious abortion, because of its wide prevalence on the ranges in this region, is probably more responsible for low calf crops than any other factor. Good calf crops are being obtained on some ranches where as many as 50 cows are bred to one bull under pasture conditions. In those instances liberal amounts of grain are being fed to condition the bull for the breeding season.

The practice of grazing down dryland corn with cattle before marketing is a practical means of utilizing corn. In some instances ranchmen have planted an acre of dryland corn for each 3 or 4 year old steer to be marketed the following fall. When the steers reached the approximate limit of fattening on the range they were turned into the cornfield. Access to pasture was given them also. As a result the cattle showed excellent finish, seemed to shrink the minimum en route to market and sold in line with grain-fed cattle.

The best system of ranching that may be applied in this region must be based on (1) control of farming land

to produce sufficient feed to meet the livestock requirement; (2) production of feed in such a manner as to get the most for the labor expended; (3) control of sufficient grazing land to allow liberal acreages per head of cattle carried, and (4) utilization of the various types of range by the kinds and classes of livestock to which the range is best adapted.

In the study of the mixed type of ranching that is being practiced in western Texas, complete information on types of organizations and methods of operation was obtained on 40 ranches which represented various combinations of cattle, sheep, and goats.

The practicability of common use of range by as many as three kinds of livestock is indisputable. It seems that the greatest competition is between cattle and goats in utilization of most of the forage plants common to the region. There were no indications of low-percentage calf, lamb, and kid crops resultant from the common use of range.

Partial analysis of the data indicates the practical possibility of expanding the cattle or sheep enterprise where the long-time outlook is favorable to that particular kind of livestock. Further, it indicates that cattle and sheep rather than goats are the kinds of livestock more adaptable to expansion because the amount of browse determines the approximate ranch capacity for goat production.

Comparison of different rates of stocking with cattle and sheep on various ranches reveals that constant observation of the range must be applied to avoid overstocking, and that the effects of overstocking are first reflected in the cattle.

Under the system of running sheep loose in fenced pastures, the important item in lowering operation costs is in the savings on labor, because herders are not used. It is very evident that this type of ranching—carrying cattle and sheep in the same fenced pastures — has practical possibilities throughout the Great Plains region where ranges are suitable to both kinds of livestock.

SHEEP, GOAT, AND ANIMAL-FIBER INVESTIGATIONS

The bureau's program of research in the problems of the sheep, goat, and animal-fiber industries has included experimental work at 21 Federal and State experiment stations, 1 commercial wool-testing laboratory, 1 mohair mill, and 1 hospital clinic for testing the value of goats' milk for infant feeding.

FARM-SHEEP INVESTIGATIONS

The importance of good pastures for farm-sheep raising is being revealed to a greater extent than ever before. Through cooperation between Purdue University Agricultural Experiment Station and the bureau, at La Fayette, Ind., it was found during the summer of 1928 that the net return per lamb above feed cost for both ewes and lambs was $6.66 more for the flock kept on pasture than for the flock fed grain and alfalfa hay in dry lot. In the summer of 1927 this advantage of pasture amounted to $4.83. Another flock was managed by running ewes and lambs on pasture and feeding the lambs grain in a creep. In the summer of 1928 these lambs netted $1.11 more per lamb than the lambs that had only pasture, while in the summer of 1927 the lambs that had only pasture netted 69 cents per lamb more than those fed grain in a creep on pasture. These and other results from this series of experiments indicate the importance of pasture as an excellent and comparatively cheap feed for lambs, although a grain supplement on pasture may be profitable, depending on the cost of the grain.

At the Animal Husbandry Experiment Farm, Beltsville, Md., the bureau's study of temporary pastures for sheep showed that corn and velvet beans led in sheep-carrying capacity per acre with 390 ewe-days grazing per acre, soybeans 329, oats and Canada peas 309, barley and oats 156, and the winter barley, which froze badly so that there was only about one-quarter of a normal crop, yielded 58 ewe-days grazing per acre. These results give a clue to the possibility of intensive use of such forage crops for sheep pastures.

Under the conditions of irrigation and dry-land farming at Newell, S. Dak., it was found that native range pasture had a carrying capacity of about one-half ewe per acre, including nursing lambs, while irrigated pastures of both alfalfa and sweetclover each had a carrying capacity of 8 ewes and their lambs per acre. In these flocks there were about 1½ lambs per ewe. While this shows that both alfalfa and sweetclover have a sheep-carrying capacity about 16 times that of the native range, it should be

understood that this native range pasture, although typical of the Newell, S. Dak., locality, is considerably better pasture than much of the open-range lands used for range-sheep production. Therefore when compared with ordinary range forage the value per acre of alfalfa and sweetclover for sheep pastures makes sheep raising on irrigated farms of this region especially profitable.

That good pasture at breeding time also helps to increase the number of lambs born was shown in the flock of breeding ewes at Beltsville, Md. Those that had extra good pasture at the time they were bred yielded 145 lambs per 100 ewes; those fed grain on ordinary pasture, 144 lambs per 100 ewes; and those that had such poor pasture as to barely maintain their weight at breeding time had only 124 lambs per 100 ewes. Careful management to have good pasture during the breeding season was rewarded by the extra 21 lambs to 100 ewes. This is typical of the trend of these experiments for the last 13 years.

Breeding studies with farm sheep at Beltsville include type fixing of purebred Southdowns, Shropshires, Hampshires, and Corriedales. The Corriedales are proving to be well adapted to this region. They breed earlier than the English mutton breeds used in these experiments. The lamb weights on May 1 averaged 50 pounds for Corriedales, 40 for Hampshires, 38 for Shropshires, and 30 for Southdowns. This relatively heavy weight of the Corriedale lambs is due in part to their greater age, all lambs having been weighed on the same day. However, this serves to illustrate that the Corriedale ewes come in heat earlier in the summer or early fall and conceive more readily than the ewes of the other three breeds. This provides a great advantage in a region where the production of early lambs is more profitable than the raising of late lambs. Furthermore, the Corriedales at Beltsville are yielding heavier fleeces than other breeds. In more than a thousand fleece weights for Beltsville ewes Corriedale fleeces averaged 44 per cent heavier than the Shropshire fleeces, 46 per cent more than those from the Hampshires, and 72 per cent more than the Southdown fleeces. The Corriedale wool being longer in staple and of comparatively light shrinkage also has some advantage in market value over the wool from the other three breeds.

At Middlebury, Vt., results of the breeding studies in farm-sheep improvement by mating grade ewes to purebred Southdown and Shropshire rams show that for commercial lamb and wool production the third top cross with purebred rams is as satisfactory as crosses having a higher percentage of pure blood, although for show purposes the higher crosses are more improved in type and uniformity.

A comparative study of 24 ram lambs and 27 wether lambs was conducted at the same station. They were raised on pasture without grain until they were 5½ months old. The rams were taken away from their mothers when they averaged about 4 months old and the wethers were left with their mothers, in accordance with the usual farm practice, until the lambs were shipped to market at the age of 5½ months. When they were appraised at the Jersey City market the wether lambs were valued at 50 cents per hundred pounds live weight more than the ram lambs, but the ram lambs weighed an average of 8 pounds more than the wethers. These 51 lambs were all reshipped to Beltsville, Md., and used in meat studies. On foot the wether lambs averaged 0.34 of a grade more choice than the ram lambs and their carcasses averaged 0.27 of a grade the better. In dressing percentage the wethers were slightly more than 2 per cent better than the rams. The fresh lean meat of the rams' legs averaged 13.6 per cent less tender than that of the wethers and when cooked averaged 6.7 per cent less tender. Other data indicated that the wethers were fatter and firmer in their fat than the rams.

RANGE-SHEEP INVESTIGATIONS

Studies of range utilization with sheep at the sheep experiment station, Dubois, Idaho, included investigations of the most extreme conditions of summer drought and frigid winter that have occurred at that station since it was first operated, in 1917. While this meant suffering to man and beast it offered opportunity for the gathering of a wealth of research data on how to utilize and manage the range to meet these extreme conditions which seem bound to recur with more or less intensity. Before the occurrence of this most extreme drought the grazing studies of this station, conducted through cooperation with the Forest Service, had shown that there were great possibilities for building up the

range forage of this region by proper use and protection of the range from overgrazing. This drought has brought out the additional fact that protection of the range forage also makes it possible to weather the hazards of extreme drought with much greater efficiency than is possible without protection.

It was also found that under such severe drought conditions the sheep respond remarkably well to a supplement of cottonseed cake. For example, the average weight of the breeding ewes in October, 1928, was 8 per cent less than their October weights averaged during the four years from 1924 to 1927, inclusive. From October 26 to November 30, 1928, the ewes on the range receiving a small allowance of cottonseed cake gained an average of 3 pounds each and those not receiving any supplement on the range lost about 10 pounds each.

Results from detailed studies on fenced grazing areas indicate that there is a close relationship between precipitation during the growing period and the forage production of spring and fall ranges as measured by actual sheep-carrying capacities. During the 6-year period from 1923 to 1928, inclusive, actual carrying capacities have been found to vary 70 per cent on this type of range, the average carrying capacity for sheep grazed under sheep-tight fence being one sheep per acre for 52 days. In 1928 the carrying capacity was only one sheep per acre for 36 days, or almost 30 per cent below the 6-year average.

The fact that rather wide seasonal variations may occur in the intermountain region and have an important influence on the range-sheep industry is demonstrated by results on lamb and wool production during different years. The average fleece weight per sheep varied almost 22 per cent in the last five years. Lamb production may also vary as widely as a result of this seasonal factor. The percentage of lambs weaned in any one year has varied from 63 to 86 per cent, and the average weight has varied from 68 to 76 pounds.

In spite of the most extreme weather conditions which prevailed during the fiscal year 1929, the average fleece weight per sheep was 11.4 pounds, or 0.4 of a pound greater than that of the 5-year average. These results are evidence of the importance to the range-sheep industry of conservative stocking of the range, the use of supplemental feed during critical periods, and the careful selection and culling of the breeding flocks.

The fifth year of an experiment to compare the lamb production of Rambouillet and Corriedale ewes was completed. It was found that the lowest average lamb production per ewe was obtained from Rambouillet ewes mated to Rambouillet rams and the highest from Corriedale ewes mated to Hampshire rams. Rambouillet ewes mated to Hampshire rams produced by weaning time 9.16 pounds more live lamb per ewe than Rambouillet ewes mated to Rambouillet rams, and Corriedale ewes mated to Hampshire rams produced 7.03 pounds more lamb per ewe than Corriedale ewes mated to Corriedale rams. The pure Rambouillet lambs were not sufficiently finished at 4 to 4½ months of age to classify as fat lambs suitable for slaughter. Both the Hampshire-Corriedale lambs and the pure Corriedale lambs had a higher degree of finish than the Hampshire-Rambouillet lambs. Ewe lambs, although slightly lighter, had a higher dressed yield and a higher carcass grading than the wether lambs. Pure Rambouillet and pure Corriedale feeder lambs were lighter than Hampshire-sired feeder lambs, and therefore more satisfactory for feeding purposes.

At the Range Livestock Experiment Station, Miles City, Mont., 300 grade Rambouillet wether lambs were divided into three uniform lots. One lot was sold in Chicago as feeders at weaning time, and two lots were used at the station in a feeding experiment to compare a ration of alfalfa hay and ground barley with a ration of alfalfa hay and a grain mixture of ground barley 7 parts, and cottonseed meal 1 part by weight. The lot receiving cottonseed meal required 4.4 per cent more hay and 3.7 per cent more grain per pound of gain than the lot received only hay and barley. The net returns per ton of hay fed were 5.7 per cent greater for the hay and barley lot. On the Chicago market the lamb carcasses from this lot graded 0.8 of a grade better than those from the lot that got the cottonseed meal. When total net returns were figured up for each of the three lots it was found that the initial value per hundredweight at Miles City was $10.04 for the lambs sold as feeders, $12.61 for the lambs fed alfalfa hay, ground barley, and cottonseed meal, and $12.97 for the lambs fed alfalfa hay and ground barley.

KARAKUL-SHEEP INVESTIGATIONS

A choice flock of Karakul sheep and a select flock of Black-faced Highland ewes were maintained at Beltsville, Md., for the work of this project. The scarcity and high prices of meritorious Karakul sheep have brought about the problem of breeding ewes of the more established American breeds to purebred Karakul rams as a foundation for the future high-grade Karakuls to be employed in the production of tight-curled Karakul lambskins for use as fur.

Previous investigations by this bureau showed that coarse-wool ewes of the more established American breeds are better adapted for mating with Karakul rams for lambskin production than ewes of the fine-wool or medium-wool breeds. Black-faced Highland sheep have coarse fleeces that are especially free from the fine-wool fibers found on ewes that produce lambskins of comparatively low value. This is the first year that the bureau has mated Black-faced Highland ewes to Karakul rams for this purpose. The resulting lambs were all graded for the pattern of the curled fibers and the luster of their fleeces at the time that each lamb was 3 days old. The fleeces averaged 70 per cent as good as the fleeces of the purebred Karakul lambs in pattern of curled fiber and 57 per cent as good in luster of fiber. The plans of this project call for studies by this same system to determine the influence of succeeding top crosses of purebred Karakul rams. Studies are also being made of the correlation of the structure of the wool fibers in the respective lambs and their parents to the pattern and luster in the lambs at 3 days old.

ANGORA-GOAT INVESTIGATIONS

Studies with Angora goats are conducted, in cooperation with the Texas Agricultural Experiment Station, at Sonora and at College Station, Tex. Breeding is the primary factor now being studied with respect to its influence on the growth and quality of mohair. The possibility of eliminating kemp from the fleeces of Angora goats by proper breeding methods has been discovered and a more refined search is now in progress to determine the most efficient method of breeding to accomplish it.

MILK-GOAT INVESTIGATIONS

The bureau's herd of milk goats was established just 20 years ago. It was started with common American goats, the first plan being to develop an American breed of improved milk goats, but by 1911 it was decided that it would be more efficient to breed the common does to purebred Swiss bucks. Since that time the herd has been developed by a system of top crossing with purebred bucks of the Saanen and Toggenburg breeds. At present the grade Saanen does are 97 per cent pure Saanen and the grade Toggenburg does are 94 per cent pure Toggenburg. A few select purebred does of both these breeds have been added to the herd and compared with the grade does. The grade does of the fifth and sixth top crosses have proved as satisfactory for milk production as purebreds of the same breeds.

A recent study of the influence of feed and methods of feeding does on their milk production shows on increase of 23.4 per cent by feeding fine-stemmed, leafy alfalfa hay and grain throughout the lactation period, supplementing their pasture with hay, over that secured by feeding coarse clover and rather low-quality alfalfa hay with grain, allowing the does no hay while on pasture. This test included 21 does. The result disproves the theory of many people that goats will do well on almost any kind of feed.

STUDIES IN WOOL AND OTHER ANIMAL FIBERS

Studies in the growth of wool have been conducted at four Federal stations and in cooperation with nine State stations. A study of the growth of mohair has also been under way in cooperation with the Texas station. These results show that the variation in the lineal growth of wool is directly associated with lateral growth, that is, as wool fibers grow longer in a given period of time they also have greater diameter and, conversely, when these same fibers make lineal growth at a slower rate they have smaller diameter, or are what is called "finer."

A study of several thousand wool clippings of four to six weeks' growth has shown that wool generally grows least in winter and most during summer and fall. Studies of mohair clippings of four-weeks' growth also show this same habit of growing slowest in winter and fastest in summer and fall. Further studies are in progress to analyze the influence of such factors as nutrition and methods of management on the growth of wool and mohair.

An experiment covering a period of 100 days was carried out to determine the influence of feeding shrimp bran on the growth of wool. Twenty ewe lambs were used, 10 of them being fed a ration of alfalfa hay, corn silage, and a daily allowance of 1 pound of a grain mixture consisting of 8 parts oats, 8 parts bran, 4 parts corn, and 2 parts linseed meal by weight. The other 10 were fed a ration the same in all respects, except that the grain mixture, instead of having the 2 parts linseed meal had 1 part linseed meal and 1 part shrimp bran. The length of wool fibers grown by the lambs receiving shrimp bran was 6.4 per cent greater and the unscoured fleece weights 3.2 per cent greater than they were for those receiving linseed meal As this is the result of only one feeding test it will be necessary to conduct additional tests before conclusions can be drawn. The Bureau of Fisheries cooperated in this test.

The bristles of 60 toothbrushes and several shaving brushes were examined for the United States Veterans' Bureau to determine whether certain large purchases measured up to specifications. The results led to the refusal of certain shipments, acknowledgments by the vendors of attempting to sell the Government brushes of lower quality than those specified, and an important financial saving to the Veterans' Bureau.

In a study of factors that influence the production, growth, and quality of wool it was found that while feed and variations in weather influenced the weight and length of wool produced, the factors of breeding and individuality were so strong that in practice they should be given important consideration. Ewes in a given band that produced the heaviest fleeces and longest staple in a year of favorable conditions of feed and weather had a strong tendency to continue producing the heaviest fleeces and longest staple in years of unfavorable conditions of feed and weather.

GOATS'-MILK INVESTIGATIONS

The work for the year in goats'-milk investigations has consisted of comparisons of goats' milk with the milk of Holstein and Jersey cows produced under controlled conditions when fed to small animals; the ascertainment of the relative vitamins A, B, C, and D, total solids, solids not fat, sugar, protein including cystine, phosphorus, calcium, iron, iodine, and other contents of these milks, and of hospital feeding arrangements with human infants. Observations from the feeding comparisons made to date indicate that there are essential nutritional differences in these milks and have furnished data of assistance in the interpretation of feeding results, with human infants, now under way at Johns Hopkins University.

In addition the surplus goats' milk has been used for work dealing with the treatment of skin affections in infants and adults due to sensitiveness to the proteins of other foods. This study is being carried out in cooperation with several doctors connected with George Washington University and in private practice in Washington, D. C.

STUDIES IN THE MEAT OF SHEEP AND GOATS

All studies in the meat of sheep and goats are a part of the cooperative project, a study of factors that influence the quality and palatability of meat. Approximately 800 lambs were used for detailed meat experiments during the year. These lambs were produced at three bureau stations and five State stations. Results show that the factors breed, feed, age, sex, and castration, all cause important variations in the quality of the meat with respect to such considerations as finish and plumpness, but some common notions about their effect on palatability are being disproved. For example, the palatability of the meat from Rambouillet lambs is proving to be as satisfactory as that of lambs of the mutton breeds, and the undesirability of the meat of ram lambs is at least not so marked as many had thought it would be.

SWINE INVESTIGATIONS

Investigations in hog production were continued during the year at Beltsville, Md., and at several field stations.

SOFT-PORK INVESTIGATIONS

Study of the influence of different varieties of soybeans on the firmness of pork when fed free-choice with corn and minerals was continued at Beltsville. Pigs with initial weights of approximately 125 pounds were used. Both hogging-down and dry-lot tests were made with the Hahto, Manchu, Sooty, and Virginia varieties, the one system of feeding serving as a check against the other. Considering this work and similar studies conducted at

Beltsville and at cooperating stations it is noteworthy that wide variation in results has been obtained.

The effects of a ration composed of ground corn and ground soybeans fed with minerals to pigs with initial weights of approximately 100 pounds were studied further during the year. The following conclusions, based on work done by the bureau with cooperating stations, were reached:

(1) Pigs with initial weights of 100 pounds or more gaining at least 1½ pounds daily on 9 or 12 parts ground corn and 1 part ground soybeans, with minerals in dry lot, through a period of 9 weeks or longer, have produced firm carcasses, in the majority of cases.

(2) Pigs with initial weights of 100 pounds or less gaining a maximum of 1 pound daily on 9 or 12 parts ground corn and 1 part ground soybeans, with minerals in dry lot, through a period of 15 weeks or less, have produced soft carcasses, in the majority of cases.

(3) Pigs with initial weights ranging from approximately 40 to approximately 70 pounds fed raw soybeans with corn and minerals in comparison with cooked soybeans with corn and minerals, both rations in dry lot, have produced carcasses of approximately the same degree of firmness at comparable finished weights.

(4) Pigs with initial weights of approximately 50 pounds gaining a maximum of 50 pounds on rations of rice polish or rice bran with tankage and minerals during an 8-week feeding period followed by a gain of at least 70 pounds on brewers' rice with tankage and minerals during a period of eight weeks or more have produced firm carcasses in the usual cases.

(5) Pigs fed low-fat rations varying widely in protein content, with dried blood the principal source of protein, have produced carcasses which were strikingly uniform in composition and firmness of fat. All rations were composed of hominy, dried blood, alfalfa meal, and minerals. Owing to the different proportions of dried blood and hominy used the nutritive ratio of the different rations varied from approximately 1:2 to 1:10.

(6) Experiments have shown that corn oil, peanut oil, and soybean oil when present in the ration, either naturally contained or as added oil, have a softening effect on the body fat which increases with increasing oil content in the ration. Cottonseed oil, on the other hand, has shown a distinct, hardening effect when added to the extent of 4 per cent of the mixture to basal rations of corn or hominy with supplements. When the quantity of cottonseed oil is increased to 8 and 12 per cent, respectively, a progressive decrease in firmness results. The 8 per cent addition of cottonseed oil produced hard or medium-hard carcasses and the 12 per cent addition produced medium-soft or soft carcasses as compared to hard carcasses on the 4 per cent addition.

Study of the appetites of individual pigs for soybeans (Manchu variety) when self-fed a corn-soybean-mineral ration was begun. Results from the first test indicate a rather wide variation in the appetites even among litter mates.

A series of tests designed to determine the influence of high-protein and low-protein rations (the protein supplied in blood meal) on the amount and character of fat stored by the hog was completed. The different rations were uniformly low in fat. No significant differences were found in the carcasses, which could be attributed to the differences in rations. In fact the similarity in the fat and water content, thickness of back fat, and firmness of fats was striking.

COOPERATIVE DIETARY STUDIES

Cooperation through the School of Hygiene and Public Health of the Johns Hopkins University with the American Dental Association in the study of diet deficiencies in pigs and their relation to teeth and skeletal development has been continued. Material from 87 pigs in the second series of pigs was preserved for laboratory use. The results confirmed those obtained in the first series of pigs, which indicated that rations deficient in phosphorus produced rachitic symptoms to a considerably less degree than those low in calcium.

Selected subjects from the second series of pigs which showed aggravated results caused by deficiencies of calcium and phosphorus have been placed on complete rations to which a corrective has been added. Marked physical improvement has been observed and these are about to be slaughtered for further evidence of remedial relief. Pigs are now being farrowed for a third series of observations on incomplete rations.

IMMUNIZING SUCKLING PIGS

During the year protective serum and virus were used in the treatment of suckling pigs for immunity to hog

cholera. At Beltsville 334 pigs were treated and at five field stations in the Southwest and Northwest 561 pigs were treated. Throughout 16 farrowing seasons at these stations, during which serum and virus were regularly used on suckling pigs, no case of hog cholera ever developed as a result of such treatment. At two of the stations hog cholera appeared on three occasions in pigs not yet treated for immunity. Those pigs and hogs which had been immunized the previous season or earlier withstood the exposure without any reaction during the outbreaks.

FIELD STATIONS

At Miles City, Mont., work is being continued on the two main projects: (1) The production of hogs that will make Wiltshire sides acceptable to the English market, and (2) the relative value of old sows and gilts as dams in pork production. In the first project purebred Yorkshire and Chester-White hogs are being bred pure and crossbred in both breeds. Seventeen Yorkshire and eighteen Chester-White sows were bred in this project to produce the spring pigs of 1928. No fall pigs are raised at this station.

During the gestation and suckling periods the sows of each breed are fed separately, thus providing data on the relative cost of production of representatives of the lard and bacon breeds.

After being weaned, the pigs were fed barley and tankage on alfalfa pasture. When they reached market weights they were shipped to Austin, Minn., for slaughter.

The purebred hogs and the crosses varied greatly in uniformity of individuals within the lots. The grading for percentage of Wiltshire sides in each lot was made by the committee, with the following results:

Yorkshires furnished 56 per cent suitable for Wiltshires.
Chester Whites furnished 60 per cent suitable for Wiltshires.
Chester-Yorkshires furnished 71 per cent suitable for Wiltshires.
Yorkshire-Chesters furnished 100 per cent suitable for Wiltshires.

From each of the lots five carcasses were selected and cured as Wiltshires, after which they were shipped to England for sale. Reports received from England indicated that the purebred Yorkshire Wiltshires were held to be more desirable than those of any of the other lots, with the Chester Whites furnishing the second most desirable Wiltshires. The Yorkshire-Chesters, which had originally shown perfect uniformity in the feed lot, at slaughter were regarded as a little heavy in the shoulders, otherwise very good for Wiltshires. The comment on the Chester-Yorkshires was that there was too much variation and as a lot they were too short and heavy in the shoulders.

In the second project there were used one lot of sows 2 years old or over, one lot of gilts farrowed by old sows the year before, and one lot of gilts farrowed by gilts. Approximately 10 sows were used for each lot. The pigs from these various groups were fattened with barley and tankage on alfalfa pasture. The spring pigs of 1928 made average daily gains as follows: Those from old sows, 1.47 pounds; those from gilts from old sows, 1.47 pounds; and those from gilts, 1.38 pounds. The feed consumption per 100 pounds of gain was 444, 430, and 399 pounds, respectively.

At the Coastal Plain Experiment Station, McNeill, Miss., the fall pigs of 1928 were used in a continuation of the experiment of feeding fall pigs a limited ration and a full feed of pasture. There were three lots as follows: (1) Self-fed corn and tankage for 14 weeks; (2) fed 1½ pounds of corn per pig daily for 8 weeks, then self-fed the same feeds for 6 weeks; (3) fed 1½ pounds of corn per pig daily for 12 weeks, then self-fed the same feeds for 2 weeks. All lots were on oats pasture. The results were as follows: Average daily gain, lot 1, 1.47 pounds; lot 2, 1.07 pounds, and lot 3, 0.81 pound. Feed consumption per 100 pounds gain was: Lot 1, corn, 332 pounds, tankage, 73 pounds; lot 2, corn, 289 pounds, tankage, 35 pounds; lot 3, corn, 260 pounds, tankage, 14 pounds. At the end of the 14 weeks all the pigs were shipped to New Orleans and sold at a uniform price.

At the Iberia Livestock Experiment Station, Jeanerette, La., there is a herd of 15 purebred Tamworth sows. The spring pigs of 1928 were used in a continuation of the cooperative soft-pork investigations, the work at this station relating particularly to rice by-products.

One lot of 26 pigs was fed rice polish, tankage, and minerals for 56 days, another rice bran, tankage, and mineral for the same time. The average daily gains were 0.97 pound and 0.84 pound, respectively, and the feeds consumed per 100 pounds gain was 299 pounds of rice polish and 31 pounds tankage, and 366 pounds rice bran and 35 pounds of tankage, respectively. These pigs were then con-

tinued for another 56 days, an equal number from each lot being fed on corn, tankage, and mineral, and brewers' rice, tankage, and mineral. The lot fed corn following rice polish gained 1.29 pounds per day and required 451 pounds of corn and 24 pounds of tankage per 100 pounds gain. At the close of the test they were sent to Beltsville for slaughter and grading. The brewers' rice-fed pigs graded noticeably harder than those fed corn.

At Ardmore, S. Dak., a breeding herd of approximately 20 purebred Duroc-Jersey sows is maintained. The spring pigs of 1928 were used in continuing the project of comparing a limited ration on alfalfa pasture and finishing in the Corn Belt with full-feeding pigs from weaning to market weight.

Sixty-eight pigs were fed 1½ pounds of corn per pig daily on pasture for 85 days, making an average daily gain of 0.53 pound, requiring 278 pounds of corn per 100 pounds gain. Sixty of these pigs were then shipped to the Kansas Experiment Station, Manhattan, Kans., where they were self-fed corn and tankage and given a limited feed of middlings and alfalfa hay for 80 days. They made an average daily gain of 1.96 pounds and consumed 357 pounds of corn, 20 pounds of tankage, 51 pounds of middlings, and 8 pounds of alfalfa hay per 100 pounds gain.

Sixty pigs were placed on full feed from weaning until they reached a market weight, about September 5. One-half had access to corn and tankage, the other half to corn, tankage, and linseed meal, all self-fed free choice. The average daily gain in each lot was 1.51 pounds. The feed consumed in the first lot per 100 pounds gain was 285 pounds corn, 33 pounds tankage; in the second, 300 pounds corn, 28 pounds tankage, and 7 pounds linseed meal.

HORSE INVESTIGATIONS

During the year the bureau's horse-breeding work was continued at the Morgan Horse Farm, Middlebury, Vt., and at the Range Livestock Experiment Station, Miles City, Mont.

Projects for the maintenance, development, and improvement of Morgan horses continued along the same lines as in preceding years, the principal investigations dealing with: Factors relating to the breeding, feeding, and management of light horses; vertebræ studies; and the correlation between the period of pregnancy of mares and the season of foaling. Interest in the Government's work with Morgan horses was again attested by the continued demand for surplus animals produced at the Morgan Horse Farm, a demand that could not be met from the supply.

Horse investigations at the Range Livestock Experiment Station centered on the production and management of purebred and grade horses of the draft and light types, the stud consisting of approximately 160 animals. The particular objects of this work are to obtain data relating to phases of production and management under range conditions.

From a study of stallion enrollment for the period of 1926–1928 in 24 States requiring the licensing of such sires used for public service, it was learned that although their numbers are gradually decreasing, purebreds are replacing the scrub and grade stallions. Data on jack enrollment in 22 States indicate that there has been an approximate reduction, in the total numbers of these sires, of 33 per cent during the last three years.

CERTIFICATION OF ANIMALS IMPORTED FOR BREEDING PURPOSES

Under the provisions of paragraph 1,506 of the tariff act of 1922 the bureau issued certificates of pure breeding for 392 horses, 6,824 cattle, 3,014 sheep, 8 swine, 1,444 dogs, and 10 cats imported during the fiscal year ended June 30, 1929, making a total of 11,692 certifications during the year. The principal breeds certified were, in numerical order, as follows: Horses—Thoroughbred, Belgian, and Percheron; cattle—Holstein-Friesian, Jersey, Ayrshire, and Hereford; sheep—Lincoln, Shropshire, Cotswold, Southdown, and Suffolk.

POULTRY INVESTIGATIONS

POULTRY BREEDING

The projects on the inheritance of egg production in Barred Plymouth Rocks, Rhode Island Reds, and White Leghorns were continued, and this year the average production per bird, especially in the Rhode Island Reds, was superior to that of any previous year. Data were also collected on the inheritance of size of egg as well as size as influenced by production.

In the Barred Plymouth Rocks the percentage of fertile eggs during the hatching season was 85.38; in the Rhode Island Reds, 87.44; and in the White Leghorns, 76.28. The apparent

cause for the rather low percentage of fertility in the White Leghorns presumably was the use of some inbred stock the previous year.

The percentage of hatchability of the fertile eggs set was, in the Barred Plymouth Rocks, 57.54; in the Rhode Island Reds, 62.87; in the White Leghorns, 56.43. These results compare favorably with those for the previous year.

Full brother and sister matings and half brother and sister matings tend to decrease hatchability by increasing both the percentage of embryos dying during the period from the first to the seventeenth days and the percentage of embryos dying between the eighteenth and twenty-first days of incubation.

Such close inbreeding affects embryo mortality from the eighteenth to the twenty-first days of incubation to a greater extent than embryo mortality from the first to the seventeenth days. Hatchability results are affected to a greater extent in the first year of inbreeding than in successive years, though there is a general decline in hatching results each year that such close inbreeding is continued.

Four pens each of Barred Plymouth Rocks and White Leghorns have been continuously inbred, full brother and sister and half brother and sister matings, for three consecutive years, during which time the percentage of fertility remained about the same from year to year, whereas the percentage of hatchability decreased regularly each consecutive year, the greatest decrease occurring the first year of the close inbreeding work. In the year just closed the inbred strains were crossed to study the influence of hybrid vigor on hatchability. In every pen the percentage of fertility was lower than the previous year, whereas the percentage of hatchability was higher. There seems to be no doubt that crossing highly inbred strains tends to increase the vigor, and it is probable that the decreased percentage of fertility in each case represents selective fertilization.

POULTRY FEEDING

An experiment to test the application of the law of diminishing increment as applied to growing chicks was conducted, using 170 chicks hatched from a pen of Barred Plymouth Rock females mated to Rhode Island Red males. The chicks were weighed individually at hatching time and every two weeks thereafter. The total amount of feed consumed by each lot was determined at the end of each 2-week period.

A mathematical study of the results indicates that the law of diminishing increment expresses the relationship between feed consumption and growth of the domestic fowl.

An experiment on the effect of feeding skim milk on the constants of the growth curve of chickens showed that for the lots receiving skim milk there was a period of high variability in live weight up to 7 or 8 weeks of age, and for the lots not receiving skim milk up to 12 weeks of age. It was also found that feeding skim milk stimulated growth during the first 15 or 18 weeks but apparently did not affect the mature weight which the birds attained, birds not receiving milk having attained approximately the same size as those receiving milk, but at a later date.

A project on factors affecting the molt was conducted. The results to date indicate that a mixture of certain inorganic sulphur compounds is effective in increasing the annual egg production of both pullets and laying hens. In one series of pens of inbred White Leghorns, the pen receiving the sulphur mixture had an annual egg production 20.7 per cent greater than the control pen. In another series of pens of White Leghorns, not inbred, the pen receiving the mixture of sulphur compounds had an annual egg production 12.4 per cent greater than the control pen for the first year, and 19 per cent greater for the second year. An experiment to determine the gross maintenance requirements of the chicken showed that the maintenance requirements of the hens having an average weight of 2,620 grams was about 72.3 grams per day of the particular feed mixture used. The gross maintenance requirements of White Leghorns weighing, on an average, 1,632 grams was estimated as being 64 grams of feed per day during the month of July. It was also estimated that these same hens required approximately 40 grams of feed over and above the maintenance requirements to produce an egg.

An experiment was conducted to determine the relative value of ultraviolet irradiation as compared with feeding cod-liver oil. Two pens of hens received ultra-violet irradiation from 10 to 12 minutes per day, while two other pens received cod-liver oil as a supplement to the basal ration.

A third set of two pens received the basal ration only. None of the three pairs of pens were allowed access to direct sunlight. Mortality during the year was about the same for each of the three different lots. It was also surprising to find that the hatchability of the eggs from the three different lots was practically the same. The egg yield in the pens receiving cod-liver oil was more than 50 per cent greater than in the pens receiving the basal ration, the production in the pens exposed to irradiation being intermediate.

BIOCHEMIC DIVISION

The work of the biochemic division, under M. Dorset, chief, consisted for the most part of chemical and bacteriological researches on problems concerning dips and disinfectants, hog cholera, tuberculin, and mallein, and meats and meat food products.

INVESTIGATIONS OF DIPS AND DISINFECTANTS

Routine laboratory analyses were made of 127 samples of disinfectants, dips, viruses, serums, and miscellaneous products.

FIELD TESTS FOR DIPPING BATHS

During the year there were prepared and forwarded to inspectors in the field the following: For testing the strength of dipping baths, 267 new test outfits for arsenical dips and supplies sufficient to make 492,200 field tests; 5 new outfits for testing lime-sulphur dipping baths and supplies sufficient to make 5,200 field tests; 2 new outfits for testing nicotine dipping baths and supplies sufficient to make 3,960 tests; supplies sufficient to make 5,200 tests for phenol in viruses, serums, and analogous products; 6 new outfits for testing casing disinfectants and supplies to make 2,550 tests.

FIELD TEST FOR SAUSAGE-CASING DISINFECTANT

During the year a satisfactory field method for determining the salt and hydrochloric acid in the disinfectant for sausage casings was devised. The salt content is controlled by hydrometer readings and the acid content by titration with standard alkaki, with simple formulas for the calculations. To save expense, certain of the local laboratories of the Meat Inspection Division now prepare the reagents for use in accordance with the methods developed.

STUDIES OF DISINFECTANTS

The investigations thus far indicate that when soak waters from hides are chlorinated sufficiently to kill anthrax spores there ordinarily remains no true excess of chlorine, that is, no chlorine either free or existing as hypochlorous acid or hypochlorites. In practice, then, killing the spores appears to be effected primarily by nitrogenous compounds of chlorine of the general nature of "chloro-amines," some of which in fact are known to possess strong germicidal powers. Since soak waters themselves may be expected to vary widely in composition, it has seemed desirable to prepare and to test bacteriologically a few pure chloro-amines and chloro-amino acids of the types most likely to occur. Such work on the products of the chlorination of ammonium compounds has been practically completed. It has led incidentally to a clarification of the conditions under which the previously hypothetical dichloro-amine is produced, and a paper on this subject is now in proof. The chemical work has also been practically completed on the formation of mono-and dichloro-methylamine and on the monochloro derivatives of glycine and alanine. The ultimate aim of the work is to correlate some appropriate chemical test for "available chlorine" with germicidal power, at least within limits serviceable for practical application.

Further studies of sodium-hydroxide solution have confirmed the findings reported last year, to the effect that it is an excellent disinfectant against *Salmonella pullorum*, *Bacillus typhosus*, *Staphylococcus aureus*, and almost all of the ordinary vegetative bacteria with the exception of the tubercle bacillus, against which it has little or no effect. Tests have shown that 2 per cent solutions of sodium hydroxide are quite effective and that solutions of that concentration are, if anything, heightened in their bactericidal power by admixture with milk of lime. The use of lime serves to prevent the conversion of the hydroxide into carbonate and also serves as a whitewash, which is desirable, since the thoroughness of the application in solutions containing lime may be easily seen. It has been found that soaps containing an excess of sodium hydroxide possess notable disinfecting power for the bacteria named above.

Coincidentally with the study of sodium hydroxide, special experiments have been conducted to develop a satisfactory disinfectant against *Mycobacterium tuberculosis* for use in the field. The disinfectants now available for practical application are limited to phenolic compounds which are not entirely satisfactory because of the odor which follows their use. This objection also applies to disinfectants used in packing houses. Considerable progress has been made on this project.

An odorless, germicidal soap for hand disinfection has been prepared, and preliminary experiments show that it has marked activity against the ordinary bacteria, including *M. tuberculosis*. The disinfecting power of this soap depends largely on the presence of orthophenylphenol. The soap is not irritating to the hands.

INVESTIGATIONS OF ANTHELMINTICS

In cooperation with the zoological division, the chemical side of a study to correlate anthelmintic efficiency with chemical structure was carried out. The halogenated hydrocarbons, about 20 in number, have been studied during the year. It has been found that anthelmintic efficiency varies with the number and position of chlorine atoms in the molecule, and that marked anthelmintic action may be obtained with monochlorinated hydrocarbons as well as those which are more heavily chlorinated. As a result of these studies new, nontoxic anthelmintics have been discovered.

TUBERCULIN AND MALLEIN

The preparation and distribution of tuberculin and mallein for official use by the bureau and State inspectors was continued. During the year the total quantity of mallein supplied was 17,810 doses, a slight increase over the preceding fiscal year.

PRODUCTION OF TUBERCULIN

The year's output of tuberculin was as follows: Subcutaneous tuberculin, 412,680 c. c.; intradermic tuberculin, 2,018,595 c. c.; ophthalmic tuberculin, 2,797,035 disks.

The total production of tuberculin in all forms during the year amounted to 12,993,179 doses.

RESEARCH WORK

Last year's report stated that a very favorable synthetic culture medium for *Mycobacterium tuberculosis* had been developed. This medium yields approximately 2 grams of bacteria, dry weight, per 100 c. c. of culture fluid. During the year just ended thousands of doses of tuberculin prepared from cultures grown on this new medium were sent to field inspectors for trial. The reports have been very encouraging. This medium is fairly expensive because of the necessity for the use of asparagine, a costly amino acid. Efforts have been made to produce asparagine cheaply and also to discover, if possible, a cheap substitute for it. Through cooperation of the Bureau of Plant Industry it has been determined that asparagine can be readily produced at a low cost from the seedlings of *Lupinus albus*. Disregarding the labor and overhead charges which would be of importance in commercial production, asparagine has been prepared from these seedlings at a cost of approximately $1.25 per pound. It is hoped that some of the chemical firms in the United States will undertake production of this important chemical, which is now obtained in the United States only by importation.

A large number of ammonium salts have been studied with the object of using them as substitutes for asparagine or other amino acids. The results have shown that ammonium malate supplies nitrogen in a form which is readily used by the tubercle bacillus, and very abundant growths of that organism have been obtained with ammonium malate as the sole source of nitrogen. This ammonium salt can be obtained at a cost of approximately 70 cents per pound, whereas the asparagine is priced at more than $22 a pound.

VITAMINS IN MEATS AND MEAT FOOD PRODUCTS

VITAMINS IN COMMERCIAL BEEF EXTRACT

A study was made of the water-soluble, growth-promoting vitamins, comprising the old vitamin B complex, in samples of concentrated beef extract obtained from five meat-packing establishments operating under Federal inspection. As a result of numerous feeding experiments with rats it was found that all samples of beef extract examined were good sources of the heat-stable, water-soluble vitamin, which is generally designated in this country as vitamin G. This vitamin is essential for growth and health and may or may not be identical with the vitamin which prevents and cures hu-

man pellagra. One pound of concentrated beef extract was found to contain approximately as much vitamin G as 9 pounds of fresh, lean beef. Beef extract was found to be poor in the antineuritic vitamin.

VITAMIN G IN BEEF, PORK, AND CERTAIN EDIBLE VISCERA

A study was also made of the relative amounts of vitamin G in lean beef, lean pork, beef spleen, beef liver, hog liver, and beef kidney. Lean beef, lean pork, and beef spleen were found to contain a moderate amount of vitamin G, whereas beef liver, hog liver, and beef kidney were much richer in this vitamin. The latter products contained approximately seven times as much vitamin G as beef or pork, and approximately as much of this vitamin as yeast.

A concentrated water extract of liver was found to be much richer in vitamin G than the liver itself. By means of the fractional precipitation of liver extract with alcohol, it was found that the fraction precipitated by 50 per cent alcohol contained very little if any vitamin G, and that the fraction precipitated by 75 and 90 per cent alcohol by weight, respectively, and the portion soluble in 90 per cent alcohol, were of approximately equal activity.

RELATION OF THE GROWTH-PROMOTING VITAMIN G TO THE ANTIPELLAGRA VITAMIN

Although the term "vitamin G" is now rather generally applied in this country to the heat-stable, water-soluble, growth-promoting vitamin and to the antipellagra vitamin, as though the two were identical, adequate experimental proof for this usage has not been offered. If the two factors are identical, then a measure of growth-promoting vitamin G in a foodstuff will also be a measure of the antipellagra vitamin in that product.

Doctor Goldberger and associates of the Public Health Service have made an extensive study of the value of certain common foods in the prevention of pellagra, but only limited data concerning the value of these foods as sources of growth-promoting vitamin G are available. For this reason a study of the vitamin G content of certain foods, previously tested by Doctor Goldberger as to their antipellagric properties, is being conducted in this laboratory by means of feeding tests with rats. Although these experiments are still in progress, the results obtained thus far indicate that the amount of growth-promoting vitamin G in a food is not an accurate measure of the antipellagra value of that food. For example, carrots, which are reported by Goldberger to be relatively poor in the antipellagra vitamin, were found to contain practically as much growth-promoting vitamin G (per unit of dry matter) as lean beef which Goldberger found to be one of our best foods in preventing pellagra.

PULLORUM DISEASE (BACILLARY WHITE DIARRHEA)

The research work on this disease has progressed satisfactorily during the year. Experiments concerning disease transmission in incubators have been carried out as follows: Four kinds of incubators were employed, two of the agitated-air type and two of the still-air type. Eggs from known pullorum-disease-free hens were incubated in these machines at the same time with eggs from pullorum-infected hens but in different parts of the machine. Simultaneously in each instance, duplicate machines were set with disease-free eggs only and operated under strict isolation from the infection. The disease-free quality of these eggs was amply established by the results of these normal control hatchings.

Chicks were removed from the incubators 18 to 24 hours after hatching and those from the several types of eggs were brooded separately for two weeks under strict isolation. All chicks that died in that time were examined bacteriologically for the presence of *Salmonella pullorum*.

These experiments showed that pullorum disease may be transmitted from diseased to healthy chicks by exposure in an incubator for 18 to 24 hours from the time of hatching, without actual contact between the chicks, and that a considerable percentage of chicks so exposed will succumb to the disease even under very favorable subsequent brooding conditions. Methods of disinfecting the incubator while the chicks are present are being studied.

An investigation is in progress to determine the relationship of death of chicks in the shell to the presence of infection in the egg.

Methods of diagnosing pullorum disease have been studied. A radical simplification of the agglutination test has been developed, by which a single drop of whole blood is sufficient to render a diagnosis. The blood drop may

be mixed with the antigen on a glass plate as soon as collected, and an immediate diagnosis may thus be made, or the drop may be collected upon a strip of filter paper of an absorbent grade, dried, and sent any distance to a laboratory for testing. The advantage of this method may be summed up as follows: The fowl, if tested in the field, need not be handled more than once, and hence requires no number band or other identification. The blood sample required is so small as to involve no detriment or inconvenience to the fowl.

The sample, if collected on filter paper and mailed to a laboratory, is in no danger of spoilage or breakage, such as fluid samples are subjected to, and may be tested equally well at any later time. Further experimental work is needed to establish definitely the reliability of this new technic.

HOG-CHOLERA INVESTIGATIONS

During the year there were prepared at the experiment farm at Ames, Iowa, 110,500 c. c. of anti-hog-cholera serum and 37,654 c. c. of virus. These products were used in connection with the experiments being carried out at Ames and in Washington as well as in connection with the experimental immunization of young pigs, a study of which question is being carried on cooperatively between the biochemic division and the animal husbandry division of the bureau. The suckling pigs farrowed at eight different farms were immunized before weaning, with satisfactory results.

During the year a large number of examinations of commercial hog-cholera serum for bacterial content have been made in cooperation with the division of virus-serum control, bacteriological studies being carried on to determine the best method of heating the serum. In addition to this routine work a certain amount of field work has been instituted in order to gather data concerning the practical questions arising in hog-cholera control work. These studies related to so-called "breaks" following the preventive treatment for cholera, studies of the origin of isolated outbreaks of hog cholera, and studies of diseases, such as necrotic enteritis, hemorrhagic septicemia, hog flu, and other conditions which tend to complicate diagnosis and thus confuse field practitioners. It is believed that this work, aside from the information gathered, is of much importance in acquainting a considerable number of farmers and veterinarians with the research work being carried on by the bureau.

STUDIES OF VACCINES

The study of vaccines prepared from organs and tissues of cholera-infected hogs has been continued. In all, up to the present time a total of 15 lots of vaccines has been produced, using as attenuating agents varying amounts of formaldehyde and chloroform. Considering all the work done, it seems to be established that susceptible pigs can be successfully immunized against cholera by means of vaccines attenuated through the use of formaldehyde and chloroform. The temperature at which the virus is maintained after being mixed with the attenuating agent is probably of much importance. The present indications are that an interval of from two to three weeks is required for the establishment of a satisfactory immunity in susceptible pigs treated with single doses of vaccine. The most desirable dose has not yet been established. In general, it may be stated that vaccines prepared from tissue pulp are promising, but that a considerable amount of further experimentation should be carried out before they are to be recommended for general, practical use.

STUDIES OF METHODS OF IMMUNIZATION

A limited number of field observations were made concerning the character of the immunity produced by the simultaneous inoculation following administration during a period of passive immunity, that is, where serum-alone inoculation is followed, within a week or 10 days, by simultaneous treatment. The field experiments carried out during the year indicated that pigs treated with serum alone and immunized by the simultaneous method of injection within a week thereafter, were rendered entirely immune. This experiment confirms entirely certain work carried out some years ago and which has been questioned by certain practitioners.

STUDY OF SERUM ABSORPTION

In some cases following simultaneous treatment the injected pigs have been found to show symptoms of disease within a short period. It was thought that this result might, at times at least, be due to slow or imperfect absorption of the injected

serum. A number of experiments were therefore carried out in which minimum doses of serum, both defibrinated blood serum and clear concentrated serum, were employed with the usual dose of virus. As a result of these studies it has been concluded that there is little, if any, difference in the rate or degree of absorption of the serum when it is administered subcutaneously, intramuscularly, or intraperitoneally. The experiments indicate, furthermore, that the intraperitoneal method seems to have, so far as the absorption of the serum is concerned, no advantage over the other two methods. In fact, the results suggest that, if anything, the absorption of serum intraperitoneally is less satisfactory than the subcutaneous and intramuscular methods. In this same connection an effort was made to determine whether or not the clear concentrated serum was materially better when used for curative purposes than the defibrinated blood serum. A number of pigs were treated, half being given defibrinated blood serum and half clear serum. The pigs when treated all showed high temperatures and were in the early stages of the disease. The number of tests thus far made is not large enough to warrant final conclusions, but they indicate that the concentrated clear serum is probably superior to the defibrinated blood serum in curative value. This may be the result of better and more rapid absorption.

STUDIES OF SERUM-VIRUS MIXTURES

In these experiments serum and virus were mixed in the proportion of 10 of serum to 1 of virus. Pigs were injected with 1 c. c. of such mixture which had stood for two hours at varying temperatures, all remained perfectly well, whereas susceptible pigs injected with an equivalent dose of virus (0.09 c. c,) all contracted the disease and developed severe hog cholera. This experiment has been repeated with similar results, thus indicating that there is a neutralization of virus by serum in vitro. Tests of pigs treated with from one to three injections of mixed serum and virus in the proportions named, show that mixtures of serum and virus in vitro prepared as indicated above are not effective for immunization.

In connection with these studies an attempt was made to determine whether or not the flocculation test, as carried out by Ramon in studies of diphtheria, could be applied in the case of hog cholera. In no case was it possible to demonstrate any flocculation in mixtures of anti-hog-cholera serum and hog-cholera virus.

TRANSMISSION OF HOG CHOLERA BY FLIES

Additional experiments with screened and unscreened pens, placed in proximity to hogs affected with hog cholera, have indicated that flies, or other insects, which are excluded by the ordinary screen may be factors in the spread of the disease. It has furthermore been noted in this connection that the greatest prevalence of hog cholera in the State of Iowa in the years 1927 and 1928 corresponded with those periods during which the stable fly was most prevalent.

BACTERINS FOR NECROTIC ENTERITIS

Since the work of Murray, Biester, and associates has indicated that necrotic enteritis is in large part, if not entirely, due to infection with bacteria of the Salmonella group, an endeavor was made during the year to determine the effect of killed cultures (bacterins) prepared from *Salmonella suis* in producing immunity against this disease. Unfortunately, it has not been possible to test the pigs immunized with bacterins against the infection as it occurs naturally in the field, but from experimental exposure to cultures of *Salmonella suis* by feeding certain facts have been developed, as follows:

(1) Bacterins prepared from several strains of *Salmonella suis* when administered in two subcutaneous doses, one week apart, appear to confer a considerable degree of protection against later exposure to virulent cultures administered by mouth.

(2) Single subcutaneous injections afforded practically no protection against later exposure.

(3) The administration of the bacterins by mouth appeared to be of little, if any, value.

(4) The exposure given to the injected pigs was quite severe. Perhaps under practical conditions where exposure might not be so severe, a single dose of bacterins subcutaneously might afford more protection.

EXPERIMENT STATION

The work of the bureau's experiment station at Bethesda, Md., conducted under the superintendence of W. E. Cotton, has consisted for the most part in the investigation of infectious abortion, tuberculosis, and

vesicular stomatitis, and in providing other divisions of the bureau with facilities and help not available in their laboratories.

INFECTIOUS ABORTION

During the year efforts were made to develop more effective and satisfactory methods of artificial immunization against infectious abortion than are now in use. There is great need for some safe and efficient method of this kind for use in herds where other means of combating the disease are impracticable. Experiments are in progress to that end.

A calfhood immunization experiment, similar in nature to that reported last year, has also been begun with a view to obtaining more definite data on that promising method of immunization.

The vaccinated animals in the original calfhood immunization investigation have now completed their second pregnant periods during which they were twice drenched with *Bacterium abortus* infected material. The results of these exposures were similar in character to those of their first pregnancies, which were described in the report of last year. The 11 vaccinated animals produced 10 living calves. In the single case of abortion which occurred, failure was experienced in incriminating *Bact. abortus* as the causal agent for the abortion. Of the 5 control animals which received the same exposure, 2 acquired the disease and 1 of these aborted.

The ever-increasing number of cases of undulant fever in man, for which the abortion microorganism is being held responsible, is emphasizing the importance of gaining more definite and comprehensive knowledge concerning biological prophylaxis. Observations by investigators engaged in the study of *Bact. abortus* infection in man, indicating that the porcine type of this organism may be a worse offender in causing human illness than the bovine type, prompted during the year a careful checking of the abortion vaccines offered for sale on the open market with the view to determining if by any chance porcine strains had entered these products. Twenty-six lots of vaccine were tested by guinea-pig inoculations, upwards of 300 guinea pigs being used for this purpose. One lot of the vaccine produced lesions in the guinea pigs inoculated with it thoroughly characteristic of those caused by the swine organism and was positively identified as such. Action was immediately taken to prevent sale of this product.

Additional data, bearing on the ability of the abortion microorganism to invade the animal through the mucous membrane of the eye, have been accumulated, which, in connection with the results of previous investigations, indicate that this route is a comparatively vulnerable one for a *Bact. abortus* attack. Whether it is of importance in nature remains to be determined.

Within the year three cows were readily infected with the disease by depositing on the conjunctival mucous membrane a few drops of an emulsion of *Bact. abortus* fetal intestinal contents. The three pregnant cows used as controls remained free from the disease. Experiments thus far indicate that a minute quantity of infection in the eye is of much more serious consequence than many times that amount in the digestive tract, now regarded as the principal route of infection. The use of the eye in conjunction with ingestion exposure as a means of determining the degree of immunity afforded by experimental vaccination has already given evidence of its furnishing an exceedingly uniform method of imparting the disease to susceptible stock.

Since several investigators have reported the finding of *Bact. abortus* in the milk of cows not reacting to the agglutination test, an effort was made to gain further data bearing on such observations. Milk samples from 25 cows, negative to the agglutination test but from a herd in which infectious abortion had existed for about 12 years, were injected into the peritoneal cavities of guinea pigs, 100 guinea pigs being used for this purpose. The guinea pigs indicated that all the milk samples were free from *Bact. abortus*, thus confirming the serological tests.

Several other projects in connection with infectious abortion also received consideration during the year. These include studies of the action of chemical agents in dealing with *Bact. abortus* infection of the udders of cows, the differentiation of the bovine and swine types of *Bact. abortus* infection in guinea pigs by the intradermic injection of antigens prepared from both types of the organisms, and experiments in connection with the intradermic injection of killed abortion bacilli as a means of diagnosing the disease in cattle. The results obtained from these

studies have not been of such a character as to give much encouragement or to suggest that the methods tested will be helpful in solving the abortion problem.

TUBERCULOSIS

More than 16 years ago an experiment was begun to determine whether the bovine tubercle bacillus would be made more virulent for hogs by continuous passage through that species of animals. This experiment is of considerable importance because of the light it throws on the stability of types of tubercle bacilli and the possible danger that a type more virulent for hogs than now exists might be evolved through intimate and long continued association of tuberculous cattle and hogs.

On May 12, 1913, an emulsion of bovine tuberculous tissue was prepared and used to inoculate two calves and two hogs. After a number of months the hogs were killed and two fresh ones inoculated with tuberculous tissue found in them. The calves also were killed and two fresh ones inoculated with similar tissue found in them. This procedure was repeated at intervals varying from six months to a year or more up to August 16, 1928, when tuberculous tissues taken from the last series of cattle and hogs were tested for virulence on two groups of five hogs each.

It was, therefore, 15 years and 3 months from the time the tuberculous material was put into the first series of animals until it was recovered from the two species of animals and inoculated into test hogs. Within that time the bacilli had undergone 25 passages through hogs and 15 passages through cattle.

All the animals used in the experiment were carefully tested with tuberculin, without reaction, before they were used. The cattle and hogs were kept widely separated from each other and there was no known exposure other than that by inoculation. As stated on August 16, 1928, both the hogs and cattle carrying the two lines of bacilli were killed and separate emulsions, prepared on the one hand from tuberculous lymph glands of the cattle and on the other from those of the hogs, were used to inoculate two groups of five hogs each. Both groups of hogs were so selected that each contained animals of corresponding age, size, and condition. The doses given to the two lots, based on the number of tubercle bacilli present, were as near alike as could be made by the use of a relatively simple technic, and the two lots of hogs were kept separate but under the same conditions.

After eight months, one animal from each group was killed. About three months later the remaining animals in each group were killed. Careful autopsies were made and the lesions found in the two groups compared. While the lesions were generalized in nearly all the animals, they were not voluminous except in one of the group receiving the hog material and in two of the group receiving that from the cattle.

A comparison of the lesions in the two groups of animals did not show any marked difference in character or volume. The little difference that there was indicated that the cattle germ was more virulent for hogs than that which had passed through hogs, but this difference was so slight that it can be accounted for in the difference in susceptibility of the individual test animals. It seems, therefore, that a sojourn of 15 years in hogs was not sufficient to modify the bovine tubercle bacillus appreciably in its behavior toward hogs.

The investigations to determine the value of the Calmette B. C. G. vaccine as an immunizing agent against tuberculosis, which have been in progress for a considerable time, were continued and a paper giving the results of the first series of experiments published.

During the year eight calves fed B. C. G. within the first 10 days of life and eight controls were added to the experiment and subjected to natural tuberculous exposure. Five animals similarly treated and their controls either died or were killed. These, with two exceptions, had been exposed for eight months or more to tuberculous cattle. While the exposure was sufficiently severe to infect nearly all of the animals, the lesions were not voluminous nor very widespread in any of them. The amount and character of the lesions in the principals and controls did not indicate that any measurable degree of immunity had been produced by the B. C. G. treatment.

As in former years, commercial tuberculins have been tested for potency and purity.

VESICULAR STOMATITIS

Because of the close similarity, in many respects, between vesicular

stomatitis and the dreaded foot-and-mouth disease and the danger of mistaking one for the other, the investigation of vesicular stomatitis has been continued.

The two distinct strains of vesicular-stomatitis virus reported last year have been preserved for study by passage through guinea pigs. One of the strains has undergone 485 passages through guinea pigs over a period of nearly three and one-half years and is still virulent for horses and cattle. It has been noted that the two strains differ slightly in their behavior toward guinea pigs in that one of them shows a rather strong tendency to cause secondary vesicles to appear several days after the primary ones have developed, whereas the other strain rarely causes other than primary vesicles.

Guinea pigs which had passed through an attack of the disease two years ago still solidly resist inoculations, which invariably bring down control animals, and of five that had passed through an attack of the disease two and one-half years previously, four resisted severe exposure to the disease.

Tests of materials and minor investigations have been made; a large number of small experiment animals have been raised, and the facilities for carrying on investigations have been improved.

FIELD INSPECTION DIVISION

For the purpose of consolidating closely related activities, public stockyards inspection and the enforcement of the 28-hour law were transferred on July 1 from the field inspection division to the packers and stockyards division. The field inspection division, under the direction of George W. Pope, continued to conduct field work incident to control and eradication of certain diseases of livestock, the administration of regulations governing the importation and exportation of livestock and those providing for the sanitary handling of hides, skins, wool, and other animal by-products, feeding materials, fertilizers, used bagging, and hay and straw packing materials offered for importation into the United States.

EXCLUSION OF DISEASES OF FOREIGN ORIGIN

While the country has continued to be free from rinderpest, contagious pleuropneumonia, and surra, it has been less fortunate in the case of foot-and-mouth disease, an outbreak of which occurred in California. The disease was diagnosed positively January 17, on a hog ranch near Montebello, in Los Angeles County. The infection was directly traceable to the feeding of meat contained in garbage taken from a merchant vessel in the harbor of San Pedro. The vessel had been on a South American cruise and had provisioned with meat in an infected country.

An order of the Secretary, effective January 19, announced the presence of the disease and placed a quarantine on that portion of Los Angeles County within a radius of 3 miles of the town of Rivera. Effective March 18 an order revoking the quarantine served to announce officially the eradication of the outbreak.

Table 1 shows the dates on which the disease was confirmed in the various herds involved, number of animals affected or exposed, their appraised value, and other data.

TABLE 1.—*Summary of the outbreak of foot-and-mouth disease in California*

Disease diagnosed	Animals affected or exposed				Date of slaughter	Disinfection completed	Appraised value of animals slaughtered
	Cattle	Swine	Goats	Total			
Jan. 17	1	3,271	------	3,272	Jan. 19	Feb. 2	$59,822.60
Jan. 30	51	------	------	51	Jan. 31	Feb. 2	10,580.00
Feb. 2	75	------	------	75	Feb. 2	Feb. 7	15,500.00
Feb. 6	33	------	------	33	Feb. 6	Feb. 8	6,410.00
Feb. 16	67	------	------	67	Feb. 16	Feb. 20	10,865.00
------	[1] 50	[1] 20	[1] 23	[1] 93	------	------	4,361.40
Total	277	3,291	23	3,591	------	------	107,539.00

[1] Livestock in vicinity of infected premises slaughtered at various dates during the outbreak on account of possible exposure.

In addition to the value of animals as shown in Table 1, property to the extent of $2,419.10 was destroyed, chiefly in connection with cleaning and disinfecting operations.

This, the ninth recorded outbreak in the United States, was of shorter duration and involved fewer animals than any previous visitation of the disease. These results were made possible through prompt diagnosis, slaughter, burial, and disinfection. Great credit is due the local veterinary authorities who made an early discovery of the disease and to the Governor of California and his officers who fully cooperated. Local business organizations also gave their hearty support. The record time in which the appraisal, slaughter, and burial of herds was accomplished was largely the result of excellent cooperation of all, including the owners of infected animals.

In accordance with the established policy which has made possible complete eradication of previous outbreaks in the United States, all diseased and exposed herds were promptly slaughtered. Other measures of quarantine and eradication were essentially those of former outbreaks. Save for the use of a 1.5 per cent solution of sodium hydroxide for disinfecting the clothing of inspectors and other workers and the use of chicken-wire fences for inclosing quarantined premises, there was no especial change in procedure. Close attention was given to the disinfection of trucks which had been used for various purposes in the quarantined area but no railroad cars were involved. This fact tends to emphasize the increasing relation of motor vehicles to problems of livestock-disease control. Although there had been an order in effect since 1927 prohibiting the landing of meat from regions in which rinderpest or foot-and-mouth disease exists, it was considered advisable to issue a further order, designated B. A. I Order 315, effective January 25, placing specific restrictions on the landing at United States ports of any garbage containing meat obtained from regions in which either of the diseases mentioned is present. This order has been strictly enforced at various ports of entry, bureau inspectors having received the full cooperation of local health and port authorities.

The bureau has continued to encourage owners and veterinarians throughout the United States to report conditions of livestock suspected to be foot-and-mouth disease in order that an investigation might be promptly made in each instance.

ERADICATION OF SCABIES

In the control and eradication of sheep scabies the bureau continued to cooperate with State livestock sanitary authorities. During the year 19,655,705 inspections were made and 2,704,256 dippings supervised by inspectors in the field. The number of sheep found to be infected was 732,937. This was an increase of approximately 8 per cent over the preceding year. Reports indicate a considerable increase in the number of infected sheep on the Indian reservations in Arizona, where climatic and range conditions have been unfavorable for eradication work. There was also an increase in the number of infected animals in California, Kansas, Kentucky, Mississippi, Oklahoma, South Dakota, and Utah, and a decrease in Colorado, Louisiana, Michigan, Nebraska, New Mexico, Texas, Washington, and Wyoming.

In the eradication of cattle scabies, bureau employees made 3,544,358 inspections and supervised 617,410 dippings in cooperation with State officials. Cattle found to be infected numbered 99,005, and while this is approximately 34 per cent less than for the preceding year there was a considerable increase in the number of inspections made. Outbreaks were reported in Oregon; there was an increase in the number of infected animals in Arizona, Colorado, and Wyoming and a reduction in Montana, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Washington. No infection was reported in California and Utah where it existed during the preceding year. The disease in Montana was confined to Indian reservations.

In view of the increasing goat industry in certain sections of the Southwest and the development of scabies in these animals, 37,243 inspections were made and 8,067 animals found to be infected. The infection was confined to the State of Texas.

The control and eradication of horse scabies on the Blackfeet Indian Reservation in Montana was vigorously conducted during the early part of the fiscal year. However, as the disease had become firmly established, complete eradication was not accomplished. There were 26,674 horses inspected, among which 4,118 were reported in-

fected and 19,964 exposed. A certain percentage of the infected animals was appraised and destroyed, as the animals were so seriously affected with the disease in the chronic form as to render treatment impracticable.

INTERSTATE SHIPMENTS OF LIVESTOCK

Bureau veterinarians, in connection with their regular duties, inspected 8,881 horses and mules and mallein tested 3,232 for glanders, to which none reacted. These inspections were made and tests administered for interstate movement and certificates were issued to conform to the requirements of the livestock sanitary authorities of the States of destination. Inspectors in the field in connection with their regular duties also made other inspections of livestock and issued certificates to conform with State requirements.

ERADICATION OF DOURINE

During the year the systematic testing of horses was accomplished in a section of western Montana and on the Navajo Indian Reservation, in Arizona, the only areas in the United States where dourine was known to exist. The limited number of reactors found in Montana—11 head—tends to indicate that further check tests which may be made in the infected areas will probably show the disease to have been eradicated in that State. Lack of funds available for use by the Office of Indian Affairs for the gathering of horses on the Navajo Reservation made it necessary for the bureau to assume this responsibility during the latter part of the year. It was possible, however, to continue the work without interruption, and, before the close of the year, make a second test of practically all horses in which infection was found during the previous season. The number of reacting horses, in what had been badly infected areas of the reservation was approximately 1.6 per cent of those tested. This small percentage leads to belief that any further tests in these areas next year, deemed necessary to establish freedom from disease, will show little if any infection. Eradication work was facilitated by the castration of approximately 600 undesirable surplus range stallions.

CONTROL OF COMMUNICABLE POULTRY DISEASES

In June a disease of poultry occurring in Morris County, N. J., believed by the State authorities to be European fowl pest, was brought to the attention of the bureau. An investigation at the center of infection, together with tests conducted at the laboratory, confirmed the diagnosis. Assistance was given the State officials in controlling and eradicating the outbreak, which was accomplished by killing and burning all infected and exposed birds and disinfecting the involved premises. Inspectors in charge at Paterson, Newark, and Jersey City, N. J., and at New York City were instructed to have observations made of poultry in the markets of those cities. No cases of the disease were found, however, and the infection was apparently confined to a definite area of the county involved. Up to the close of the year the source of infection had not been determined.

The bureau continued to supervise the cleaning and disinfection of cars used in the interstate transportation of live poultry. This work was accomplished for the most part at three central disinfecting stations, and 10,492 cars were treated during the year.

INSPECTION AND QUARANTINE OF IMPORTED ANIMALS

A careful inspection was made of all horses, ruminants, and swine from foreign countries when presented for entry at coast or border ports. Owing to the established rule of the department to issue no permits for the importation of domestic ruminants and swine from countries in which foot-and-mouth disease or other serious disease of livestock exists, animals of this kind have consisted chiefly of those from Canada and Mexico and purebred cattle from the Channel Islands. As England experienced repeated outbreaks of foot-and-mouth disease during the year, no cattle, sheep, or swine were allowed entry from that country. A few shipments of cattle and sheep were received, however, from Scotland, and several consignments of purebred sheep from New Zealand. Buildings and other equipment at the quarantine stations for the ports of Boston, New York, and Baltimore were well maintained. The station for New York at Athenia, N. J., was connected with the public water system, affording a higher pressure than that of the station pumping plant, which was in need of costly repairs and was abandoned. A concrete breakwater was constructed along the waterfront at the station for the port of Baltimore at Turner, Md., this being necessary to protect the land from erosion. The number and kinds of animals imported are shown in Tables 2 and 3.

TABLE 2.—*Imported animals inspected but not quarantined*

Port of entry	Cattle	Swine	Sheep	Goats	Horses and mules	Asses	Other animals
Boston	4				81		6
Houston					6		1
Key West					724		
Los Angeles					4		
New York					1,071	45	41
Philadelphia					20		
San Francisco					4		
San Juan, Porto Rico	1,246	71		5	118	4	4
Canadian border ports	252,612	2,750	14,295	51	6,087	1	336
Mexican border ports	316,965	215	23,130	201	6,775		16
Total	570,827	3,036	37,425	257	[1] 14,890	50	404

[1] Of this number 5,299 were mules.

NOTE.—Animals passed through United States territory under bond for return to their respective countries and inspected at the time of entry were as follows: Canada, 3 cattle; Mexico, 1,046 cattle.

TABLE 3.—*Imported animals inspected and quarantined*

Port of entry	Cattle	Swine	Sheep	Goats	Horses	Asses	Other animals
Baltimore							52
Boston			121			1	48
Los Angeles					1		
New York	1,393		8	1			73
San Francisco			52		13		5
San Juan, Porto Rico	16	2	2	2			
Seattle							2
Canadian border ports	949	44	18	3		2	8
Mexican border ports							
Total	2,358	46	201	6	14	3	188

Prior to their release from quarantine, 1,393 cattle from the Channel Islands and Scotland, shown in Table 3 as having been imported at New York, were subjected to a tuberculin test without any reactions. Eleven cattle from Canada were rejected when presented for entry through failure to pass a satisfactory tuberculin test.

In cooperation with the Bureau of Biological Survey, 87,131 quail from Mexico were inspected and quarantined by inspectors of the bureau at time of entry at border ports.

Inspectors at coast ports made special efforts to obtain strict enforcement of the regulation designed to prevent vessels from entering ports of the United States with sea-stores livestock originating in countries in which foot-and-mouth disease or rinderpest exists. Surgeons of the Bureau of the Public Health Service of the Treasury Department, in their function as boarding quarantine officers, rendered material aid in the enforcement of this requirement. During the year 41 vessels carrying prohibited livestock were held pending slaughter of the animals and disinfection of the section of the vessel occupied by them. These animals consisted of 7 cattle, 36 swine, 29 sheep, and 15 goats.

IMPORTATION OF ANIMAL BY-PRODUCTS, FEEDING MATERIAL, ETC.

Effective May 1, previous regulations governing the sanitary handling and control of hides, fleshings, hide cuttings, parings, glue stock, sheepskins, and goatskins and parts thereof, hair, wool, and other animal by-products, hay, straw, and forage or similar material offered for entry into the United States were superseded by B. A. I. Order 313. The new regulations were made very comprehensive and in addition to hides, skins, other animal by-products, and feeding materials they included previously used bags and bagging. The purpose of these regulations has been to prevent the introduction of anthrax, foot-and-mouth disease, and rinderpest from foreign countries into

the United States. To handlers and manufacturers of import by-products, anthrax has presented the chief problem whereas to the bureau foot-and-mouth disease has been a matter of greater concern. From present knowledge of this disease it has not been possible to know the exact degree of danger attendant upon the importation of various products, but those against which the bureau has maintained restrictions are believed most likely to carry infection.

A careful supervision over such materials has been maintained at various coast and border ports and when not accompanied by proper sanitary certificates or otherwise eligible for release, movement has been permitted only in sealed cars or other conveyances or tight containers to approved tanneries or other plants in the United States for handling under supervision of the nearest available bureau inspector. Provision has been made for the disinfection of these materials in the regular process of manufacture, thus entailing the least possible inconvenience and expense to importers. During the year 9,257 railroad cars used in the transportation of restricted import materials were cleaned and disinfected.

INSPECTION OF ANIMALS FOR EXPORT

Care has been taken in the inspection of all export livestock and so far as conditions have warranted certificates are issued to meet the requirements of receiving governments. Inspectors at ports of embarkation have supervised the fitting of vessels for the safe and humane transportation of livestock and have issued export certificates as required by the regulations for animals destined to countries overseas. Cattle for dairy and breeding purposes have in all cases been tuberculin tested and horses have been subjected to a mallein test when so desired by authorities of the country of destination.

In accordance with an agreement with the Canadian authorities, practically all dairy or breeding cattle and horses crossing the border into Canada have been tuberculin and mallein tested, respectively. Sheep and goats destined to Canada have been inspected and in some instances dipped twice under supervision of a bureau inspector. Swine for export to Canada have in nearly all instances been accompanied by a bureau certificate of inspection and as a rule have been immunized against hog cholera before shipment.

The number of animals of various kinds inspected for export is shown in Table 4.

TABLE 4.—*Inspection and testing of animals for export*

Kind of animals	To Canada	To other countries		Total
		American animals	Canadian animals [1]	
Cattle	1,111	1,501	9	2,621
Swine	78	294	----------	372
Sheep	780	329	----------	1,109
Goats	19	5	----------	24
Horses	4,072	613	1	4,686
Mules	58	6,113	----------	6,171
Asses	4	40	----------	44
Other animals	----------	1,483	----------	1,483
Total	6,122	10,378	10	16,510

[1] Animals of Canadian origin exported through United States ports.

DIVISION OF HOG-CHOLERA CONTROL

During the year efforts to control losses from hog cholera were continued as in the past, under the supervision of U. G. Houck, chief of the division, in cooperation with State livestock officials, farmers' organizations, and practicing veterinarians.

Again the preventive-serum treatment has been the dependable factor in the fight against hog cholera. As heretofore, investigations of reported outbreaks have been made and advice and assistance given in the suppression of these outbreaks. Demonstrations and meetings have been held to show the proper use of anti-hog-cholera serum and hog-cholera virus in protecting swine herds against hog cholera. Approximately 37 bureau veterinarians devoted their time to this project.

As shown in Table 5, which is a summary of the work, the number of hog-cholera outbreaks during the year, reported from all sources, was 7,029.

TABLE 5.—*Summary of hog-cholera-control work, fiscal year 1929*

State	Bureau veterinarians engaged in work [1]	Meetings addressed	Premises investigated	Demonstrations		Autopsies performed	Farms quarantined or carded	Farms cleaned and disinfected	Outbreaks reported to bureau veterinarians
				Number	Hogs treated				
Alabama	1	33	1,376	36	486	23			8
Arkansas	1.5	54	1,006	93	1,110	41		17	875
California	.25	6	75	6	518	49	5		41
Colorado	.25	2	100	1	38	50			13
Florida	1.25	16	985	652	12,783	84			240
Georgia	1.3	23	1,123	164	3,111	94			311
Idaho	1	38	879	21	749	64	29	7	31
Illinois	3	34	2,211	22	886	723	313	393	962
Indiana	2	87	1,046	1	250	207	30		146
Iowa	2	16	645	10	721	198			504
Kansas	1		1,374	12	126	46			39
Kentucky	2	10	2,232	102	5,930	200	9	10	179
Louisiana	1	4	400	35	1,239	31			60
Maryland	2	15	2,928	26	614	195	652	3	956
Michigan	2		581	30	1,586	146		1	298
Mississippi	1.03	17	1,819	290	3,304	25			23
Missouri	1	49	943	22	898	107			312
Nebraska	.5	8	509			216			86
North Carolina	2	9	1,169	227	4,349	125	126	26	89
Ohio	1	6	468	11	665	69			258
Oklahoma	2	13	1,904	21	1,043	107	86		167
South Carolina	1		660	652	10,516	27			591
South Dakota	1	1	374			77			69
Tennessee	1	9	877	50	1,324	78	99	16	143
Texas	.83	2	655	1	50	9			145
Virginia	1	49	894	28	840	96		9	157
Washington	1		721	1	240	56	14		44
Oregon	.5	4	137	16	522	9	8	4	21
West Virginia	1	3	440	57	993	63	10		183
Wisconsin	1	3	408	61	1,132	111	60	3	78
Total	37.41	511	28,939	2,648	56,023	3,326	1,481	489	7,029

[1] Fractions denote veterinarians devoting part time to hog-cholera work.

Hog cholera was diagnosed in 3,093 cases and other swine diseases in 1,396 as the result of investigations. There were quarantined or carded 1,481 farms on which cholera infection was discovered. Of these, 489 were cleaned and disinfected under the supervision of field inspectors. A total of 28,939 visits were made to farms to observe conditions as they pertained to cholera, other swine diseases, and sanitation. In the year's work bureau inspectors interviewed 86,218 persons, including farmers, practicing veterinarians, and others in the interests of more effective hog-cholera control. This work extended to 841 counties of the 31 States with which the bureau has cooperative relations in combating this disease. The number of visits made by bureau inspectors to render services has ranged from 1 to as high as 292 in a county.

EDUCATIONAL ACTIVITIES

Educational activities were conducted in communities needing further instruction in hog-cholera control. As a part of this phase of the work field inspectors participated in 691 meetings attended by 70,515 persons. The proper use of the preventive-serum treatment was demonstrated in 2,182 instances, 38,255 hogs being treated. Practicing veterinarians were assisted by bureau inspectors in immunizing 466 herds, numbering 17,768 hogs. In localities where no veterinary services were readily available, 19 laymen were trained to administer the preventive-serum treatment.

At the beginning of the fiscal year a modified plan of hog-cholera-control work was adopted in Alabama, Arkansas, Florida, Georgia, Mississippi, and Louisiana. Tennessee, Virginia, and North Carolina are also now following this plan. Instead of statewide activities, the project is restricted to a selected territory within the State. In such areas efforts are made to encourage the use of the preventive-serum treatment and the adoption of sanitary methods in the raising of swine. The plan of work is conducted in close cooperation with agricultural extension workers, the aim in view being to stimulate swine growing by showing farmers that cholera need not be a deterring factor if proper precautions are taken.

MEAT-INSPECTION DIVISION

The work of the Federal meat-inspection service, conducted under R. P. Steddom, chief, shows a decrease of 1.8 per cent in the total number of animals slaughtered, as compared with the number during the previous year, and an increase of 4.2 per cent over the average total number of animals slaughtered during the last 10 years.

GENERAL MEAT INSPECTION

Inspection was conducted at 801 establishments in 253 cities and towns as compared with 829 establishments in 255 cities and towns during the fiscal year 1928. Inspection was inaugurated at 27 establishments and withdrawn from 34, as compared with 33 and 37, respectively, during the preceding year. Inspection was withdrawn from these establishments on account of the discontinuance of slaughtering, interstate or regular business, or upon request. At the close of June 30, 1929, the number of establishments operating under inspection was 775, as compared with 783 at the close of June 30, 1928.

TABLE 6.—*Ante-mortem inspection of animals*

Kind	Passed	Suspected [1]	Condemned [2]	Total
Cattle	8,073,088	212,875	153	8,286,116
Calves	4,509,293	8,270	30	4,517,593
Sheep	13,763,831	5,238	29	13,769,098
Goats	21,276	11		21,287
Swine	47,056,547	115,836	4,155	47,176,538
Horses	116,868	10	8	116,886
Total	73,540,903	342,240	4,375	73,887,518

[1] This term is used to designate animals suspected of being affected with disease or condition that may cause condemnation in whole or in part on special post-mortem inspection.
[2] For additional condemnations, see Tables 7 to 10, inclusive.

ANTE-MORTEM AND POST-MORTEM INSPECTIONS

The ante-mortem and post-mortem inspections are given in Tables 6 to 11, inclusive.

TABLE 7.—*Post-mortem inspection of animals*

Kind	Passed	Condemned	Total
Cattle	8,222,446	61,878	8,284,324
Calves	4,517,461	8,863	4,526,324
Sheep	13,748,730	20,135	13,768,865
Goats	21,206	78	21,284
Swine	47,024,155	139,418	47,163,573
Horses	116,473	404	116,877
Total	73,650,471	230,776	73,881,247

Tables 8, 9, and 10 show the diseases and number of condemnations on ante-mortem and post-mortem inspections.

TABLE 8.—*Diseases and conditions for which condemnations were made on ante-mortem inspection*

Cause of condemnation	Cattle	Calves	Sheep	Swine	Horses
Abscess				180	
Blackleg	1	1			
Bone disease				3	
Car sickness	2				
Emaciation	6	4		13	
Enteritis		1	1	2	
Hog cholera				2,629	
Immaturity		4			
Injuries	14	1	3	9	
Metritis	1		1		
Moribund	40	10	11	136	
Necrobacillosis				12	
Pneumonia	60	3	1	93	1
Pyrexia	15	4	4	1,042	
Rabies	2				
Septicemia, pyemia, uremia	11	2	8	36	
Strangles					5
Tetanus	1				2
Total	153	30	29	4,155	8

TABLE 9.—*Diseases and conditions for which condemnations were made of the entire carcass on post-mortem inspection*

Cause of condemnation	Carcasses					
	Cattle	Calves	Sheep	Goats	Swine	Horses
Actinomycosis	371	28			1	
Anthrax					104	
Asphyxia	2	2	6		1,618	
Blackleg	9	14				
Bone disease	143	125	275		5,630	1
Caseous lymphadenitis			2,405	6		
Cellulitis					75	
Contamination		1			1,155	
Cysticercosis	123	23	198		61	
Dropsical diseases	34		29		48	2
Emaciation	6,508	1,532	5,804	55	902	13
Frozen					1	
Gangrene	35	11	1		2	
Hog cholera					23,175	
Hydronephrosis					7	
Icterus	84	132	991	1	4,118	
Immaturity		2,379		1		23
Injuries, bruises, etc	2,744	549	742	6	1,879	16
Johne's disease	8					
Leukemia	1,170	33	7		222	1
Melanosis	17	38	27		101	10
Moribund	14	3	6		27	
Necrobacillosis	22	1			3	
Necrosis	1				2	
Parasitic diseases	26	1	48		85	
Phlebitis		74				
Pneumonia, peritonitis, enteritis, pleurisy, etc	11,649	2,263	7,465	5	28,125	140
Pregnancy and recent parturition	16		1		39	
Rabies	1					
Septicemia, pyemia, uremia, etc	5,223	984	1,862	4	19,138	60
Sexual odor			1		3,365	
Skin diseases		4	3		107	
Strangles						31
Tetanus					1	
Texas fever	38	57				
Tuberculosis	31,254	512	1		46,624	
Tumors and abscesses	2,386	97	263		2,803	107
Total	61,878	8,863	20,135	78	139,418	404

TABLE 10.—*Diseases and conditions for which condemnations were made of parts of carcasses on post-mortem inspection*

Cause of condemnation	Parts of carcasses				
	Cattle	Calves	Sheep	Swine	Horses
Actinomycosis	85,542	1,803		1	
Bone disease	13	15	15	483	
Caseous lymphadenitis			4		
Cellulitis				537	
Contamination	70	207	16	2,739	
Cysticercosis	242	7	8		
Injuries, bruises, etc	802	98	138	29,508	
Melanosis	18	4		1	
Necrobacillosis		22			
Necrosis	1,044		2		
Parasitic diseases	147			6	
Tuberculosis	43,935	597		402,419	
Tumors and abscesses	6,585	2,109	83	376,851	2
Total	138,398	4,862	266	812,545	2

Table 11 shows the total combined condemnations on ante-mortem and post-mortem inspections.

TABLE 11.—*Summary of condemnations*

Kind	Live animals and whole carcasses	Parts of carcasses
Cattle	62,031	138,398
Calves	8,893	4,862
Sheep	20,164	266
Goats	78	
Swine	143,573	812,545
Horses	412	2
Total	235,151	956,073

In addition the carcasses of 51,212 animals found dead or in a dying condition were tanked, as follows: Cattle, 4,070; calves, 3,166; sheep, 7,969; goats, 44; swine, 35,725; horses, 438.

TABLE 12.—*Meat and meat food products prepared and processed under supervision*

Product	Inspection
Cured:	*Pounds*
Beef	134,866,183
Pork	2,992,898,044
All other	1,181,623
Sausage	785,462,578
Canned:	
Beef	208,425,549
Pork	67,656,023
All other	5,661,467
Product passed for cooking:	
Beef	3,277,436
Pork	6,770,374
All other	1,727
Pork to be eaten uncooked	47,416,596
Meat extract	39,232
Lard	1,817,601,307
Lard oil	20,509,247
Lard stearin	3,330,234
Compound and other substitutes for lard	467,077,010
Oleo stock and edible tallow	62,118,412
Oleo oil	111,178,374
Oleostearin	55,234,677
Oleomargarine	158,880,708
Miscellaneous	1,982,571,440
Horse meat:	
Cured	10,146,436
Canned	4,065,232
Miscellaneous	327,575
Total	8,946,697,484

NOTE.—The following quantities of meats and meat food products were condemned on reinspection and destroyed for food purposes on account of having become sour, tainted, unclean, rancid, or otherwise unwholesome: Beef, 2,097,258 pounds; pork, 6,255,056 pounds; mutton, 28,658 pounds; veal, 20,361 pounds; goat meat, 115 pounds; horse meat, 11,525 pounds; total, 8,412,973 pounds.

INSPECTION OF MEAT AND PRODUCTS

The inspection and supervision of meat and products prepared and processed are shown in Table 12, which is a record only of inspection performed and not a statement of the actual quantity prepared. The record of inspection is sometimes duplicated when the product is reinspected during the different stages of preparation.

Market inspection, to facilitate interstate delivery of meat and products, was conducted in 26 cities.

MEAT AND PRODUCTS CERTIFIED FOR EXPORT

During the fiscal year a total of 86,093 official meat-inspection certificates were issued to cover the exportation of the following products: Beef and beef products, 107,639,398 pounds; mutton and mutton products, 2,316,543 pounds; pork and pork products, 1,109,949,073 pounds; horse-meat products, 8,712,602 pounds; total, 1,228,617,616 pounds. There were also issued 4,269 certificates covering the exportation of 50,179,299 pounds of inedible animal products.

EXEMPTION FROM INSPECTION

The provisions of the meat-inspection law requiring inspection usually do not apply to animals slaughtered by a farmer on the farm or to retail butchers and dealers supplying their customers. The retail butchers and dealers, however, in order to ship meat and meat food products in interstate or foreign commerce, are required to obtain certificates of exemption. The number of such certificates outstanding at the close of the fiscal year was 1,052. During the year 78 certificates were canceled on account of dealers retiring from business or ceasing to make interstate shipments, change of address, insanitary conditions, violations of the meat-inspection regulations, and handling inspected meat only.

During the year 43,611 shipments were made by retail butchers and dealers holding certificates of exemption, as compared with 47,927 shipments during the fiscal year 1928. The shipments of the year covered products as shown in Table 13.

TABLE 13.—*Shipments by retail butchers and dealers under certificates of exemption*

Product	Carcasses	Pounds
Beef (209 quarters)	52	25,907
Veal	25,907	2,039,715
Sheep	509	22,012
Swine	151	16,399
Beef, fresh		1,575,359
Veal, fresh		170,901
Mutton, fresh		326,398
Pork, fresh		159,707
Cured meats		388,122
Lard		11,517
Sausage		57,413
Miscellaneous (scrapple, lard substitutes, suet, head-cheese, etc.)		58,879
Total	26,619	4,852,329

During the year 63,732 interstate shipments were made of meat and meat food products from animals slaughtered by farmers on the farm, as compared with 64,222 shipments made during the fiscal year 1928. The products composing these shipments are shown in Table 14.

TABLE 14.—*Shipments of farm-slaughtered products under exemption from inspection*

Product	Carcasses	Pounds
Beef (428 quarters)	107	41,105
Veal	62,246	4,857,707
Sheep	3,724	102,335
Swine	1,978	180,543
Beef, fresh		9,838
Veal, fresh		76,673
Mutton, fresh		768
Pork, fresh		124,377
Cured meats		469,892
Lard		27,114
Sausage		158,874
Miscellaneous (scrapple, pudding, etc.)		27,808
Total	68,055	6,077,034

INSPECTION OF IMPORTED MEAT

Table 15 shows the inspection of imported meat and meat food products for the fiscal year.

TABLE 15.—*Imported meat and meat food products inspected and passed*

Country of origin	Fresh and refrigerated meat		Canned and cured meat	Other meat products	Total weight
	Beef	Other classes			
	Pounds	*Pounds*	*Pounds*	*Pounds*	*Pounds*
Argentina			36,153,615	1,503,670	37,657,285
Australia	227,887	1,213,188	504	246,010	1,687,589
Brazil			3,775,269	53,638	3,828,907
Canada	19,020,396	11,921,231	17,961,324	7,179,737	56,082,688
New Zealand	32,451,876	2,570,239	218,592	219,329	35,460,036
Paraguay			2,936,211	36,410	2,972,621
Uruguay			27,626,560	920,993	28,547,553
Other countries	1,385,129		839,778	1,403,428	3,628,335
Total	53,085,288	15,704,658	89,511,853	11,563,215	169,865,014

Table 16 shows the quantities of foreign meat and products excluded from the country because of unsoundness, presence of prohibited preservative, or other failure to comply with the regulations.

TABLE 16.—*Imported meat and meat food products condemned and refused entry*

Product	Condemned	Refused entry
Beef	14,498	54,423
Veal	1,475	
Mutton		329
Pork	7,647	10,643
Total	23,620	65,395

IMPORTATION OF ANIMAL CASINGS

During the fiscal year foreign animal casings were admitted as follows: On certification, 21,145,410 pounds; on disinfection, 1,291,851 pounds; total, 22,437,261 pounds. Casings amounting to 45,619 pounds offered for importation were rejected and removed from the United States.

INSPECTIONS FOR OTHER BRANCHES OF THE GOVERNMENT

By request of other branches of the Government, reinspections of meat and meat food products were conducted, as shown in Table 17, to determine whether the articles remained wholesome and conformed to certain specifications.

TABLE 17.—*Inspections for other branches of the Government*

Branch of Government	Passed	Rejected
	Pounds	*Pounds*
Navy Department	45, 276, 256	1, 488, 920
Veterans' Bureau	2, 947, 483	324, 757
Marine Corps	2, 331, 850	36, 243
Department of Justice (Federal penitentiaries)	1, 448, 610	54, 063
War Department (Army Engineering Corps)	773, 106	29, 320
Department of Interior (Indian Affairs)	645, 705	2, 663
Coast Guard	381, 164	2, 124
Public Health Service	373, 699	44, 534
Alaska Engineering Commission	78, 885	100
Shipping Board	60, 532	1, 002
Total	54, 317, 290	1, 983, 726

MEAT-INSPECTION LABORATORIES

Analyses and examinations of meat and products were conducted in the meat-inspection laboratories situated in the several districts throughout the country.

The total number of samples examined was 44,522, of which 1,270 represented meat and meat food products offered for importation. Samples of 2,508 domestic and 246 imported products were found to be not in accordance with the regulations. Included in these were examinations of meats and meat food products, edible fats and oils, cereals, spices, curing materials, colors, denaturing oils, water supplies, and miscellaneous materials.

About 1,800 samples of water were examined for evidence of pollution. All findings of pollution were followed by corrective action.

Changes in requirements for the denaturing of rendered fats derived from condemned and inedible products led to the collection and examination of large numbers of samples of denaturing agents and of inedible fats.

Analyses of the flesh of immature calves furnished additional demonstration of the scientific soundness of the meat-inspection regulations governing the disposition of such carcasses.

Samples representing canned whole hams and canned chopped-pork products were examined and the keeping qualities of the canned products investigated. The investigation showed the necessity of adequate curing and processing to insure the keeping quality of such products.

Several attempts to accomplish the artificial coloring of meat and meat food products by the use of highly colored materials of condimental nature were discovered and checked by the laboratories.

Determinations of the salt contained in the sour bone marrow of "marrow-sour hams," which showed the sour marrow to have taken up as much salt in the curing process as did the sound, sweet marrow of unaffected hams, furnished additional proof that the spoilage of hams and other pork products in cure commonly results only from faults of refrigeration.

LABELING MEAT AND MEAT FOOD PRODUCTS

During the year 17,503 labels and other markings for meat and meat food products were approved for establishments in this country and 943 were disapproved. In addition to the above materials all labels and markings for products offered for importation were handled. Numerous changes in the labels on imported products were necessary before they were acceptable for entry into this country.

PACKERS AND STOCKYARDS DIVISION

The duties of the packers and stockyards division, under A. W. Miller, chief, were increased on July 1, 1928, through the transfer to it of the administration of the livestock quarantine and transportation laws and regulations, from the field inspection division.

The work of the division, as conducted during the year, involved, under the packers and stockyards act, supervision over the operations and practices of the packers, stockyard companies, market agencies, and dealers, and rates and charges for stockyard services, and under the livestock quarantine laws and regulations, the inspection of all livestock received at public stockyards, the enforcement of the 28-hour law, and cooperation with the various States in the application of their laws and regulations designed to prevent the introduction of animal diseases.

FORMAL PROCEEDINGS UNDER THE PACKERS AND STOCKYARDS ACT

A summary of formal dockets, in which proceedings were instituted or cases decided during the fiscal year involving violations of the provisions of the act or the reasonableness of rates and charges for stockyard services, is given in the following statement:

FORMAL DOCKETS

Pending July 1, 1928	18
Instituted July 1, 1928, to June 30, 1929	16

Final action taken July 1, 1928, to June 30, 1929	20
Pending June 30, 1929	14

SUBJECT MATTER OF DOCKETS

Stockyard rates	5
Commission rates	8
Solvency	4
Trade practices	7
Bonds	8
Reparation	2

FORM OF ACTION

Cease and desist orders	5
Cease and desist orders and suspension	4
Cease and desist orders and records prescribed to be kept	1
Order fixing rates and awarding reparation	1
Continued until further order	1
Orders of suspension	3
Dismissed	5

The policy of the bureau has been to dispose of formal dockets as expeditiously as possible. Of the 16 dockets instituted during the year, final action was taken on 12. The details of each of the formal dockets are given in a separate publication which may be had on request to the bureau.

CASES IN COURT PERTAINING TO THE PACKERS AND STOCKYARDS ACT

In Docket No. 136, a court of three Federal judges in a decision filed July 28, 1928 (American Livestock Commission Co. et al. *v.* United States, 28 F. (2d) 63), issued an injunction against the Secretary in the boycott case at Oklahoma City. The case was appealed to the United States Supreme Court by the Government, and on May 20, 1929, that court reversed the order of the lower court, and sustained the Secretary of Agriculture in his order against certain market agencies and dealers, ordering them to cease and desist from boycotting certain independent concerns. The decision in this case was of more than ordinary interest, in that it involved the boycott of a cooperative agency, and the consideration of a State statute under which the agency was organized and operated. It further laid down a valuable precedent for the bureau with regard to the authority of the Secretary in bringing about the discontinuance of unfair practices.

On July 14, 1928, the special master appointed by the Federal court at Omaha handed down an opinion with respect to the order of the Secretary fixing commission rates at the Omaha stockyards, holding that the Secretary had no authority to fix such rates and that the rates which he did fix were confiscatory. A Federal district court of three judges at Omaha reversed the master's opinion in a decision filed December 18, 1928 (Tagg Bros. & Moorhead et al. *v.* United States, 29 F. (2d) 750), and held that the Secretary had authority to fix the rates, and that the rates fixed were just and reasonable. The court on February 15, 1929, ordered these rates to go into effect and they became effective February 25. The commission men appealed the case to the United States Supreme Court, and it has been set for hearing before that court on October 21, 1929.

A suit was instituted in the United States district court at Chicago in 1927 against the B. S. Pearsall Butter Co., Elgin, Ill., seeking to recover forfeitures because of failure of that company to file an annual report. A demurrer was filed by the company and overruled by the court. On January 12, 1929, judgment by consent was entered against the company in the sum of $1,000, and a check, payable to the Treasurer of the United States, was given by the company. It also filed complete information called for in annual reports for the years 1926, 1927, and 1928.

Traders at the Kansas City stockyards filed a suit to enjoin the Secretary, the Attorney General, and the District Attorney from enforcing an order requiring the filing of annual reports of their business operations. The Department of Justice prepared and had ready for filing suits to recover forfeitures from the traders for failure to file their reports. By agreement with counsel for the traders the suit to enjoin the Secretary was withdrawn, all the traders submitted annual reports covering their operations for the years 1927 and 1928, and the Government did not file its suits to recover forfeitures.

On May 28, 1928, the Secretary issued an order requiring Roberts & Oake, packer respondent, to provide an adequate bond to secure the performance of its obligations in the purchase of livestock at public markets. Roberts & Oake filed a suit in the United States district court at Chicago to enjoin the order of the Secretary. The Government filed its answer, and by order of the court an answer on the part of the respondent was due to be filed on April 15, 1929. The case was still pending at the end of the fiscal year.

STOCKYARDS

During the year two stockyards were posted as coming within the jurisdiction of the act, and six were released.

At the close of the year the number of stockyards posted under the act was 71.

REGISTRATIONS

The status of the active registrants on June 30, 1929, is shown in Table 18.

TABLE 18.—*Number of commission men and other market agencies and dealers registered*

Class	Number of agencies handling—						
	All species	Cattle	Hogs	Sheep	Horses and mules	Other	Total
Market agencies:							
Commission men	760	4	2	10	17	24	817
Order buyers	116	75	26	9	1	24	251
Clearing agencies [1]							44
Miscellaneous [2]							180
Total market agencies							1,292
Dealers:							
Buyers	845	600	225	127		339	2,136
Traders	89	545	160	41	16	51	902
Buyers and traders	69	54	13	4	2	32	174
Miscellaneous	31	14				12	57
Total dealers							3,269
Total registrants							4,561

[1] Does not include commission men and order buyers who render clearing services.
[2] Does not include commission men and order buyers who render miscellaneous services.

During the year 177 market agencies and 455 dealers were registered, and 196 market agencies and 526 dealers were placed on the inactive list.

RATES AND CHARGES

Very few changes were made in rates and charges for stockyard services during the year other than the usual changes in feed charges resulting from market fluctuations. All changes were scrutinized, and if a proposed increase did not seem warranted, the stockyard owner or market agency was requested to withdraw the tariff. If this was not done, or the reason for the increase was not satisfactorily explained, the bureau recommended formal proceedings for the purpose of determining the reasonableness of the rates.

Following an extensive inquiry, the Secretary, in his order of November 19, 1926, prescribed reasonable rates and charges for buying and selling livestock on a commission basis at the Omaha market. This order was sustained by a Federal district court of three judges. Following this decision the rates prescribed in the Secretary's order went into effect on February 25, 1929, and those market agencies on the Omaha market that were not parties to this suit voluntarily filed tariffs in conformity with the provisions of the Secretary's order.

Several stockyard owners proposed a readjustment of their rates and charges by reducing materially the spread between the cost and selling price of feed and by increasing the yardage charges. The decreased revenue on feed would be offset by the increased revenue from yardage. This matter is under consideration.

Satisfactory progress has been made in the stockyard rate study which has been carried on at 10 of the leading markets. The field work in connection with the origin and disposition of livestock at these markets was finished in the fall of 1928, and a detailed study of the information obtained, carried on in the Washington office, was nearly completed. This information will throw light on the competitive relationship of the markets and the influence of railroad rates and other factors on the movement of livestock to these markets.

During the year the valuations of the stockyards at Kansas City, Mo., and National Stock Yards, Ill., were practically completed, and those of the stockyards at Denver, Colo., South St. Joseph, Mo., and Nashville, Tenn., were brought up to date. The general stockyard rate investigation progressed sufficiently to enable the bureau to proceed to hearings in the near future for the purpose of estab-

lishing a basis for the determination of reasonable rates and charges for stockyard services.

BRAND INSPECTION

In response to requests received from a number of livestock associations, the Secretary authorized the charging and collection of a brand-inspection fee at a number of markets. This action was based on a provision in the agricultural appropriation act of February 16, 1929, which empowers the Secretary, whenever necessary, to authorize the charging and collection, from owners, of a reasonable fee for the inspection of brands appearing on livestock, subject to the provisions of the packers and stockyards act, for the purpose of determining the ownership of the livestock. This provision prohibits the imposition of such fee except on written request made to the Secretary by the board of livestock commissioners or duly organized livestock association of the States from which the livestock originates or has been shipped to market.

In Docket No. 278, Sol Dickerson *v.* Portland Union Stock Yards Co., a corporation, Portland, Oreg., the question was raised as to whether brand inspection is a stockyard service. In an order of May 29, 1929, the Acting Secretary found that the inspection of brands is a stockyard service, and fixed a reasonable fee to be charged for such service.

TRADE PRACTICES

Supervisors continued their activities in assisting in the revision of tariffs and regulations of market agencies and stockyard companies, and made numerous investigations and reports on general marketing conditions. A large number of complaints both formal and informal were received by the bureau and carefully investigated, either by supervisors or by special investigators in the field. In a great many instances, the facts did not disclose any violations of the act. In some, certain unsatisfactory conditions which were found were corrected informally, and in others formal notices of inquiry were issued.

A case involving a boycott of an independent commission firm at the Omaha market (Docket No. 246), on which a finding had been made by the Secretary, again came up for consideration. As it was found that the respondents had not discontinued the practices complained of, the case was reopened at a hearing, beginning December 10, 1928, and oral arguments were presented to the Secretary on January 21, 1929. On February 9 the Secretary in a finding severely condemning the practice of boycotting ordered all the offending agencies and dealers to cease and desist. A number of the respondents were suspended for a period of 15 days, the effective date of the suspension order, however, being withheld pending further action by the Secretary. Subsequent to this, practically all the agencies and dealers affected by the order resumed trading relations with the independent agency, and at the close of the fiscal year conditions in this respect were so much improved that it was unnecessary to put into effect the suspension orders previously issued.

Representatives of soap manufacturers informally complained that packers manufacturing naphtha soap, powders, and chips were not being required to follow the practices laid down in an order issued by the Federal Trade Commission against nonpacker soap manufacturers. This order, in substance, required that soap labeled "naphtha" or its equivalent should contain not less than 1 per cent of naphtha at the time it reached the ordinary consumer. Following an investigation of this matter by the bureau, which included laboratory analyses of packer products containing naphtha, the manufacture and sale of so-called naphtha soap powders and chips by the packers was discontinued, as had been done by nonpacker soap manufacturers. The packers altered their formulas and methods of manufacture so that naphtha bar soap would retain at least 1 per cent of naphtha until the time it was purchased by the consumer.

Several complaints received from so-called independent cream buyers and butter manufacturers, regarding alleged price discrimination and monopoly on the part of packers engaged in the purchase of cream and butterfat, were carefully investigated but in no case were sufficient facts found to warrant the issuance of a formal notice of inquiry.

Hearings were held before the House Committee on Agriculture during the fiscal year, at which considerable testimony was given regarding the practices of packers in the direct purchase of livestock, especially hogs, at points other than public stockyards. As a result of this testimony, and a number of informal complaints which had been made, the bureau conducted

an extensive survey of a large number of packer concentration and buying points in the States of Iowa, Minnesota, Nebraska, and South Dakota. A careful study was made of methods of operation and procedure in the purchase of livestock by various packers, with a view to obtaining definite information as to the practices followed, and for the purpose of determining whether any apparent violations of the packers and stockyards act existed. A mass of information, which was collected, compiled, and analyzed, provided the bureau with essential data regarding direct buying as it pertains to the packers and stockyards act.

BONDS

Market agencies and dealers generally have complied with the bond requirements. In a few instances where bonds were not furnished and informal action failed, formal proceedings were instituted to effect compliance with the bond regulations.

SCALES AND WEIGHING

During the year additional stockyards obtained scale-testing equipment of the character recommended by the bureau to test their scales at the capacity at which they are commonly used. The use of this equipment has resulted in an improvement in the condition and accuracy of these scales, as shown by the fact that of 62 scales adjusted with its aid 57 were found to need no further adjustment after several months' service. Assistance was rendered to stockyard companies in the standardization of test weights. Weight supervisors also cooperated with State employees in the testing of selected groups of farm scales.

AUDITS AND ACCOUNTS

During the year audits and investigations were made by bureau accountants of the books and records of a number of stockyard companies, market agencies, and dealers at several of the markets. The matters involved were trade practices, the financial condition of registrants, and, in some cases, general investigations of the operations of market agencies, dealers, and stockyard companies. The field auditors continued their examination of the books and records of 10 of the larger stockyards, in connection with the study that is being made of stockyard operations, for the purpose of determining the reasonableness of the rates. At the end of the fiscal year, this accounting work was practically completed.

Special effort was made to bring the auditing of all posted stockyards up to date, and there remained only a relatively few of the smaller yards where the records had not been examined and audits made covering operations for the calendar year 1928.

For the first time annual reports were received from all classes of agencies and persons subject to the provisions of the act. As indicated in the section of this report dealing with cases in court involving the packers and stockyards act, certain traders, who had resisted the efforts of the bureau to obtain reports, finally agreed to submit them, and at the close of the year reports had been received from practically all traders. The data compiled from traders' reports are shown in Table 19, and relate solely to those persons who were engaged strictly in a trading or speculative business. Information compiled from the reports received from packers, stockyard companies, and market agencies is shown in Tables 20 to 26, inclusive. These reports cover business during the calendar year, with a few exceptions which are on the basis of the fiscal year. The tables afford a perspective of the volume and character of the business conducted by persons subject to the provisions of the act.

TABLE 19.—*Financial results of operations during 1928 for 680 packers subject to the packers and stockyards act, grouped according to federally and nonfederally inspected slaughtering and nonslaughtering concerns*

Group	Number of concerns	Average net worth [1]	Net sales	Net gain
Federally inspected slaughterers	193	$788,845,670	$3,443,730,694	$44,719,089
Nonfederally inspected slaughterers	274	40,785,859	222,037,083	3,456,249
Nonslaughterers [2]	213	154,074,401	432,119,038	22,028,909
Total	680	983,705,930	4,097,886,815	70,204,247

[1] These figures represent the numerical average of the total net worth of reporting concerns at the beginning and end of their fiscal years.

[2] This group includes concerns which also handle commodities other than meat food products.

In addition to the complete reports from 680 packing concerns, financial details, lacking in some respects, were received from 139 other packers for the year 1928.

TABLE 20.—*Comparison of the operations of packers subject to the packers and stockyards act, 1924–1928*

Item	1924, 525 concerns	1925, 514 concerns	1926, 580 concerns	1927, 611 concerns	1928, 680 concerns
Average net worth [1]	$889, 919, 110	$940, 268, 445	$989, 916, 117	$970, 772, 548	$983, 705, 930
Total income	3, 321, 964, 071	3, 816, 528, 294	3, 758, 972, 700	3, 877, 621, 354	4, 110, 095, 060
Total expenses	3, 245, 075, 725	3, 751, 970 047	3, 699, 943, 922	3, 839, 325, 046	4, 039, 890, 813
Net gain	76, 888, 346	64, 558, 247	59, 028, 778	38, 296, 308	70, 204, 247
Per cent of gain to net worth	8. 63	6. 87	5. 96	3. 94	7. 14

[1] These figures represent the average of the total net worth of all reporting concerns at the beginning and end of their fiscal years.

STOCKYARDS POSTED UNDER THE PACKERS AND STOCKYARDS ACT

TABLE 21.—*Summary of consolidated balance sheets of 67 posted stockyards at close of year 1928* [1]

Assets	Amount	Liabilities	Amount
Current	$10, 803, 242	Current	$2, 677, 431
Fixed	135, 522, 444	Other	35, 537, 248
Other	11, 536, 756	Capital and surplus.	119, 647, 763
Total	157, 862, 443		157, 862, 443

TABLE 22.—*Summary of consolidated profit and loss statements of 67 posted stockyards for year 1928* [1]

Income:	
Yardage	$11, 916, 971
Feed sales	13, 321, 402
Income—Continued.	
Loading and unloading	$1, 705, 549
Rent	2, 046, 370
Miscellaneous operations	2, 365, 327
Gross operating income	31, 355, 620
Expenses:	
Salaries and wages	6, 518, 897
Cost of sales—feed	7, 337, 365
Depreciation	1, 899, 940
Taxes (excluding Federal income tax)	1, 572, 973
Miscellaneous operating expenses	5, 538, 904
Total operating expenses	22, 868, 081
Net operating profit	8, 487, 539
Other income	611, 737
	9, 099, 276
Other deductions	1, 565, 757
Net profit	7, 533, 519

[1] Two yards deposted and reports from four yards waived for year 1928.

TABLE 23.—*Summary of reports from stockyard companies subject to the packers and stockyards act, 1924–1928*

Item	1924, 58 concerns	1925, 62 concerns	1926, 65 concerns	1927, 69 concerns	1928, 67 concerns
Total average net worth	$113, 225, 257	$115, 888, 752	$116, 327, 131	$118, 071, 659	$119, 274, 997
Gross income	30, 793, 413	37, 406, 167	36, 086, 366	35, 108, 893	31, 355, 620
Net gain	7, 440, 867	6, 672, 983	6, 561, 847	6, 829, 009	7, 533, 519
Per cent of gain to net worth	6. 57	5. 76	5. 64	5. 78	6. 32

LIVESTOCK COMMISSION AGENCIES

TABLE 24.—*Number and class of market agencies reporting, 1928*

Class	Number of agencies reporting—	
	For the full year	For part of the year
Old-line agencies	650	59
Cooperative agencies	28	
Horse and mule agencies	15	
Total	693	59

TABLE 25.—*Summary of consolidated operating statement of livestock commission agencies*

Item	1926, 683 agencies	1927, 729 agencies	1928, 752 agencies
Total commissions earned	$23,110,922	$23,017,604	$23,331,401
Operating expenses (exclusive of owners' salaries)	15, 966, 507	16, 186, 814	16, 223, 981
Net operating profit	7, 144, 415	6, 830, 790	7, 107, 420
Other income	978, 048	1, 267, 499	1, 126, 666
Other expenses	62, 177	35, 351	38, 589
Return to owners	8, 060, 286	8, 062, 938	8, 195, 497

TABLE 26.—*Summary of consolidated profit-and-loss statement of 909 traders on 39 markets for 1928* [1]

Item	Dockage [2]	Animals handled	Weight	Amount
Cattle:				
658 traders on 36 markets—	*Pounds*	*Number*	*Pounds*	*Dollars*
Selling data		3, 477, 879	1, 752, 509, 052	242, 795, 065
Cost data		3, 478, 479	1, 743, 941, 774	235, 682, 708
Sheep:				
67 traders on 20 markets—				
Selling data		1, 745, 289	102, 951, 445	15, 489, 854
Cost data		1, 747, 225	101, 912, 535	14, 730, 582
Horses and mules:				
7 traders on 3 markets—				
Selling data		20, 515		2, 613, 990
Cost data		20, 515		2, 302, 291
Hogs:				
224 traders on 26 markets—				
Selling price	2, 661, 172	4, 047, 664	834, 918, 944	81, 096, 334
Cost price	3, 060, 367	4, 038, 204	829, 841, 105	79, 327, 364
All species:				
909 traders on 39 markets—				
Selling price				341, 995, 244
Cost price				332, 042, 945
Gross trading profit				9, 952, 299
Clearance commissions received				19, 255
Other income				245, 829
Total earnings				10, 217, 383
Expenses:				
Salaries and wages (other than owners)				1, 627, 596
Clearance commissions paid				558, 566
Feed				2, 385, 506
Yardage				332, 016
Other expenses				1, 539, 658
Total expenses				6, 443, 342
Return to owners				3, 774, 041

[1] Does not include traders who were engaged also in order-buying business. Some of the traders handled more than one species.

[2] Represents deduction in weight at time of sale because of quality or condition of the animal. This practice applies only to hogs.

CONTROL OF INTERSTATE TRANSPORTATION OF LIVESTOCK

In connection with supervision over the interstate transportation of livestock to prevent the spread of animal diseases, bureau employees inspected 18,665,970 cattle, of which 23,819 were dipped under supervision in order that they might continue in interstate commerce. They also inspected 24,296,456 sheep for communicable diseases, and 638,969 of these were dipped under bureau supervision to comply with regulations of the department or of the States of destination. Swine to the number of 41,625,123 were inspected, and the immunization and disinfection against hog cholera of 471,902 of these were supervised in order that

they might be distributed to country points for feeding and breeding purposes.

Efforts looking to a reduction of losses among feeder and stocker cattle on account of hemorrhagic septicemia were continued. Sections of public stockyards in which that class of cattle is handled, as well as all railroad stockyards regularly used in the feeding, watering, and resting of livestock, were cleaned and disinfected under bureau supervision as in previous years. The bureau cooperated with various organizations having to do with the transportation and marketing of livestock in formulating recommendations and disseminating information to livestock raisers relative to methods of handling and treatment designed to prevent the development of the disease.

During the year 20,903 cars carrying animals affected with communicable diseases were received at bureau stations. In conformity with department regulations or on request of Canadian Government officials, State officials, or transportation companies, 39,878 cars were cleaned and disinfected under bureau supervision.

The careful inspection by experienced veterinary inspectors of all ruminants and swine received at public stockyards for foot-and-mouth disease was continued as in former years.

ENFORCEMENT OF TRANSPORTATION AND QUARANTINE LAWS

Bureau employees have continued to report alleged violations of the 28-hour law which limits the time of confinement of animals in cars without feed, water, and rest. Apparent violations to the number of 415 were reported to the solicitor of the department for presentation to the Attorney General. Penalties to the amount of $27,750 were imposed in cases decided in favor of the Government. The evidence was collected and the reports prepared largely by employees stationed at public stockyards as a part of their regular duties with only four employees devoting their entire time to that work. Further improvements in facilities for the feeding, watering, and resting of livestock in transit were arranged for at a few points. There were also submitted for prosecution during the year 57 cases of alleged violations of the quarantine laws and regulations, and fines amounting to $3,150 were imposed in the cases decided in favor of the Government.

PATHOLOGICAL DIVISION

Under the direction of John S. Buckley, chief, the pathological division has followed its usual line of scientific investigation of the diseases of domestic animals and birds, the poisoning of livestock by plants, and the examination of viruses, serums, and other remedies used in the treatment or prevention of diseases of domestic animals.

DIAGNOSIS AND CONTROL OF DISEASES

GLANDERS

Cooperative work for the control and eradication of glanders in the various States was continued. The complement-fixation test was applied to 576 samples of serum from animals suspected of being affected with or exposed to the disease, 48 of which gave positive reactions.

DOURINE

In the course of the campaign for the control and eradication of dourine, 9,781 samples of blood serum from horses in districts where dourine is present or suspected were subjected to the complement-fixation test, and 156, or approximately 1.6 per cent, gave positive reactions.

TESTING ANIMALS FOR IMPORT

Blood-serum samples from 85 horses and donkeys offered for import were subjected to the complement-fixation test for glanders and trypanosomiasis before the animals were admitted.

WORK WITH JOHNIN

A limited number of tests were made with johnin, injected intravenously, for the diagnosis of paratuberculosis of cattle. Fair results were obtained.

TULAREMIA IN SHEEP

A sheep disease which has existed in some areas of southern Idaho for several years, causing considerable losses among lambs, was investigated by a bureau representative. Wood ticks, *Dermacentor andersonii* Stiles, taken from the fore quarters of an affected lamb and the prescapular lymph glands from the same animal, were forwarded to Washington. Inoculation tests with guinea pigs resulted in the death of these animals, revealing lesions of acute or subacute tularemia at autopsy. In each case *Bacterium tularense* was recovered

from the spleen, liver, and lungs by culturing on the coagulated egg-yolk medium. The primary cultures were transferred to cystine agar (Francis) and typical growths of *Bacterium tularense* obtained. Saline suspensions of the subcultures were inoculated subcutaneously into fresh guinea pigs and typical lesions of tularemia produced in every instance, deaths ensuing in from five to eight days following inoculation.

Field observations indicate that rabbits and ground squirrels, which serve as hosts to the ticks during the larval and nymphal stages, are very numerous throughout the territory where the sheep disease is prevalent, and at times there is high mortality among the jack rabbits. The ticks generally attach themselves in small groups on the front of the body of sheep, the most favorable sites being the breast and inner sides of the forelegs.

The symptoms shown by affected sheep are a tendency to lag behind the band, lie down much of the time, show evidence of diarrhea, lameness in one or both forelegs, temperature ranging from 104° to 108° F., rapid loss in weight, extreme prostration, and coma preceding death. The disease is usually more severe in lambs than in adult sheep. A mixture of pine tar and a hydrocarbon oil applied with a paint brush is quite effective in killing attached ticks and also has some repellent effect. Rather rapid recovery is the rule if ticks are killed or removed before the disease becomes advanced.

FOWL PEST

In June, 1929, a suspected outbreak of European fowl pest in New Jersey was reported to the bureau. A representative was immediately sent to confer with the officials of the State and to make a thorough investigation of the outbreak. He also obtained specimens of the disease for further study. A diagnosis of European fowl pest was confirmed on the grounds of selective pathogenicity, filterability of the virus, and the characteristic nature of the lesions.

AUTOPSIES ON ANIMALS FROM THE NATIONAL ZOOLOGICAL PARK

Forty-three animals from the National Zoological Park were autopsied in an effort to determine the cause of death, which was established in 36 cases.

RABIES

One hundred and twenty-seven suspected cases of rabies were received and subjected to laboratory examination. These included 75 positive cases in dogs, of which about one-half were from the District of Columbia, most of the remainder being from adjoining counties in Maryland and Virginia. Several were received from West Virginia and Kansas. Besides these, 10 cats were received, 8 of which proved to be affected with rabies and 2 were negative. Ten specimens from suspected rabid cows were received, 7 of which proved to be positive. Specimens from 2 horses were received, 1 of which was positive. Some of the material received for the examination was in such poor condition that no satisfactory examination could be made. Whenever a person was bitten and the microscopic examination failed to show the characteristic changes, experimental animal inoculations were made. A total of 84 persons, mostly dog and cat owners or their children, were bitten or scratched by affected animals. Most of the specimens were received in the months of April, May, June, and July.

INVESTIGATIONS OF POULTRY DISEASES

During the year 755 poultry specimens were received. Examination revealed the usual diseases common to poultry, including bacillary white diarrhea of chicks, *Salmonella pullorum* infection of adult birds, coccidiosis, roup, diphtheria, chicken pox, infectious bronchitis, blackhead, fowl cholera, fowl typhoid, and tuberculosis.

The agglutination test for the detection of *Salmonella pullorum* infection was applied to 2,214 adult-chicken blood specimens from the bureau's farm at Beltsville, Md. Of this number 59 gave positive reactions.

Baby-chick specimens were received from various sections of the country, the majority originating in Maryland, Virginia, Pennsylvania, and New Jersey. Ninety per cent of the baby chicks under 10 days of age revealed definite evidence of bacillary white-diarrhea infection.

RESEARCH ON DISEASE PROBLEMS

TUBERCULOSIS STUDIES

In an importation of 100 cattle, a 2-year-old heifer reacted to the ophthalmic and intradermic tuberculin tests. These tests had been applied

at the close of the quarantine period, about two months after the original test which had been made before shipment of the cattle to this country and had resulted negatively. At autopsy no visible lesions were found except a small nodule about 4 or 5 mm. in diameter in the left median lobe of the lung. This material was forwarded to the bureau and a pure culture of a tubercle bacillus corresponding to the human type was recovered from lesions produced in guinea pigs by inoculation with specimens of the nodule.

Autopsy of a young, gray spider monkey (*Ateles geoffroyi*) from the National Zoological Park revealed lesions of generalized tuberculosis, from which a culture of human-type tubercle bacillus was isolated.

ANAPLASMOSIS INVESTIGATIONS

Investigations of anaplasmosis were continued at the Washington laboratory and in the field. A cow in which the disease had been experimentally produced by inoculation of virulent blood on August 13, 1927, having made a complete recovery after several weeks' illness, was found to be harboring the parasite, *A. marginale*, as late as April 25, 1929.

Observations in Florida during the year show that the affection is most prevalent during the warm months of the year, from March to September. The sodium cacodylate treatment was used with considerable success, particularly when given during the early stages of the disease. Of 161 clinical cases treated, there was a loss of only 19 head. During the period October 24, 1927, to February 2, 1928, 1,218 cattle had been inoculated with the incubation virus vaccine. Since that time very few of those cattle have shown clinical symptoms of anaplasmosis and only one case has been fatal.

VACCINATION OF DOGS AGAINST RABIES

Experimental work on the prophylactic vaccination of dogs against rabies was continued during the year. Vaccines rendered avirulent or killed by formalin, phenol, and chloroform were tested for their ability to produce immunity in dogs. Limited experimental work with vaccines, prepared by the addition of 1 per cent chloroform which rendered the vaccine avirulent, conferred a high degree of immunity to dogs, as shown by their ability to withstand an intramuscular injection of rabies street virus. Chloroform-treated vaccine appeared to afford a higher degree of protection than vaccine prepared with phenol and formalin, although the latter two in several instances showed protective value.

DEGENERATIVE CHANGES IN BOVINE LIVERS

Experimental studies of degenerative changes in bovine livers, associated with yellowish coloration, included histological, bacteriological, and chemical examinations of such livers, and also rat-feeding experiments. In groups of cattle so affected, the liver condemnations at slaughtering establishments have been, in some instances, as high as 50 per cent of the total number. The yellowish coloration was found to be caused by carotin deposits in the liver; rat-feeding experiments also showed the presence of a toxic substance in the affected livers. Further studies are being made to ascertain the nature of that substance.

STUDIES OF WARTS IN CATTLE

Experimental studies of common warts in cattle have shown definitely that bovine warts are of an infectious nature, that warts can be transmitted in cattle with a fair degree of regularity, and that the causative agent is of the nature of a filterable virus. These results are significant in view of the injurious effect of large warts on hides.

STUDIES OF BOVINE LEUKEMIA

Experimental studies of bovine leukemia indicate that this disease is not of infectious origin. Bacteriological tests of affected tissue gave negative results. Efforts to transmit the disease to animals of the same or different species by inoculation of blood and glandular material from affected animals also gave negative results.

INFECTIOUS ANEMIA OR SWAMP FEVER OF HORSES

Answers to a questionnaire sent to all State veterinarians as to prevalence of swamp fever indicated that this disease had existed in 17 States during the last five years. Reports from 14 States indicated that the disease was on the decrease, while 3 States reported an increase and considered it to be an economic problem.

Mississippi reports the disease to be very prevalent and that it was of considerable economic importance.

During the year three field studies were made of this condition as it exists in Mississippi in the Delta section where the infection was reported to be well established. These studies were made at different seasons of the year. It was observed that losses were confined to the Delta area which is subject to occasional floods. The impression gained during these field surveys has been that the diet of the animals may be an important factor responsible for the condition. When the animals were fed a balanced ration no losses occurred.

Feces from mules and horses in the Delta were also examined and it was shown that a heavy infestation with the parasites, strongyles, and cyclicostomum, existed. At a conference with practicing veterinarians of the Delta, measures were inaugurated to treat certain lots of mules to rid them of parasites. The results from such treatment have been very satisfactory. The general condition of these animals has improved and no losses were recorded.

Examinations of the blood of a number of animals in the Delta, suspected of being affected with swamp fever, were made but in no instance was any evidence of anemia noted.

SCABBY BARLEY

Studies with scabby barley were undertaken dealing particularly with the relationship between such barley and the abnormal conditions observed in hogs fed on it. Information of value has been obtained through bacteriological, chemical, and hog-feeding tests. These investigations are being continued.

TESTING BIOLOGICAL PRODUCTS

In cooperation with the division of virus-serum control a large number of products and cultures of organisms intended for use in the preparation of various biologics was examined. Of the products more than 18 per cent were found unsatisfactory on account of bacterial contamination, lack of potency, or presence of injurious substances. Likewise 42 per cent of the cultures were rejected as unsuitable because of contamination, not being true to type, or nonviability.

INVESTIGATION OF STOCK-POISONING PLANTS

During the year the investigations of stock-poisoning plants were largely in continuance of those of former years and under the same general plan of work. The experiment station at Salina, Utah, used for these studies, was kept open from June 1 to September 30. Most of the experimental work was carried on there, while the laboratory and summarizing work was conducted chiefly at Washington, D. C.

Following are brief statements in regard to the work on individual plants which gave definite results during the year:

APOCYNUM ANDROSAEMIFOLIUM, "DOGBANE"

Feeding experiments showed quite conclusively that this plant could not be considered a stock-poisoning plant.

ASTRAGALUS TENELLUS

Feeding experiments indicate that this plant should not be considered as in the stock-poisoning class.

CICUTA OCCIDENTALIS, "WATER HEMLOCK"

A few experiments of feeding the fruit showed that this particular part of the plant was somewhat toxic for sheep, but not sufficiently so to make it dangerous for livestock on the range.

HYPERICUM PERFORATUM, "ST. JOHN'S WORT"

This plant has become a weed pest on the ranges of northern California, and the question has been raised whether it would be dangerous to livestock. Experimental work conducted in cooperation with the University of California has shown quite conclusively that the plant as growing on the ranges of northern California can not be considered dangerous to livestock.

LUPINUS

A few feeding experiments were begun with various species. While most of the lupines cause losses of sheep rather than cattle, it was determined that *Lupinus caudatus* and *L. laxiflorus*, two of the California species, are distinctly poisonous to cattle.

MALCOLMIA AFRICANA

Feeding experiments indicate that this is not a stock-poisoning plant.

LOCO INVESTIGATIONS IN SOUTHWESTERN UNITED STATES

A special congressional appropriation made possible an extensive survey of western Texas and New Mexico with respect to the distribution of the suspected loco plants and the losses occasioned by them. In the Texas area there appear to be at least two loco plants which have never been investigated as to their effects on livestock. Large quantities of these plants were obtained and will be fed experimentally.

TOXICOLOGICAL INVESTIGATIONS

During the year chemical and toxicological investigations of animal diseases were continued. The principal results dealing with plant poisons were as follows:

LOCO

Study of the active principle of *Oxytropis lambertii* was continued to determine the chemical constitution of that substance. A paper embodying the results of the study of loco disease and describing the active principle was published in the Journal of Pharmacology and Experimental Therapeutics, May, 1929.

A study was made of the active principle of *O. albiflora* with the result that this substance appears to be identical with or closely related to the active principle of *O. lambertii.*

MILKSICKNESS, "TREMBLES"

A paper on Milksickness the result of richweed poisoning, was published in the Journal of the American Medical Association, July 28, 1928. Another paper describing the toxicity of tremetol, the substance responsible for milksickness and trembles was published in the Journal of the American Veterinary Medical Association, September, 1929.

Further study of the active principles of rayless goldenrod has produced final proof that this substance is identical with the tremetol previously isolated from richweed and therefore the disease produced by both plants is tremetol poisoning.

LUPINES

Work on these plants has been continued. Two new species were studied this year and yielded alkaloids.

CAROTINOSIS

An extensive study of "yellow livers" was made with the result that the coloring matter was shown to be carotin. These livers were found to contain a definite toxic substance, making the livers unfit for food. Extracts were made which contained this toxic substance.

BRANCH LABORATORIES

CHICAGO

The branch pathological laboratory at Chicago, Ill., conducted investigations of diseases in meat food animals similar to those of previous years. These investigations consist principally in making diagnoses of diseased conditions in animals slaughtered in establishments operating under the Federal meat inspection.

In addition, several hundred cold-storage chickens were examined for the Federal food, drug, and insecticide laboratory in Chicago. Most of the chickens were culls, and a very high percentage of tuberculosis was found in them. A number of other diseases, such as leukemia, enteritis, peritonitis, and pyemia, were encountered, and some of the chickens were found to be in various stages of decomposition.

As in former years, a number of exhibit specimens of interesting pathological conditions were prepared for department exhibit purposes.

DENVER

During the year 546 specimens were received for examination. They consisted principally of pathological tissues from various species of animals.

Considerable time was spent in field and laboratory studies of anaplasmosis in cooperation with the State agricultural colleges of Kansas and Oklahoma. In a transmission experiment a cow succumbed to an acute attack of anaplasmosis 23 days after subcutaneous inoculation of 5 c. c. of virulent blood. Her calf, a few months old, developed only a slight febrile reaction of short duration following injection of 20 c. c. of virulent blood. Other field observations tend to show that cattle under 1 year old are less susceptible than older animals. Microscopic examination of tabanids (horseflies) 30 minutes after feeding on infected blood, showed well-defined anaplasmata in undigested red cells. After four hours the parasites were found to be completely digested.

A transmission experiment with lice resulted negatively. Evidence accumulated thus far indicates that ticks are more likely the carriers than other insects. Dipping and feeding experiments are now in progress.

OMAHA

Specimens received for examination at this laboratory during the year numbered 450. Of these 223 were specimens from cattle reacting to the tuberculin test, which showed no lesions on post-mortem examination. The remaining 227 specimens were from various species of animals and presented a variety of pathological conditions.

TICK ERADICATION DIVISION

The work of eliminating Texas or tick fever in cattle from the United States through the eradication of the tick which transmits this disease was continued under the direction of R. A. Ramsay, chief, in cooperation with cattle owners and State and county officials in the infested Southern States.

PERSONNEL AND POLICIES

The field activities in this project were continued under the direction of nine field stations up to June 1, when one station, that located at Suffolk, Va., was closed on account of cattle-fever ticks having been completely eliminated in that district. At the close of the fiscal year the bureau had 289 veterinarians and other employees in the field working in cooperation with 807 State inspectors and 90 county inspectors.

The importance of horses and mules as factors in continuing tick infestation in areas where this work is in progress becomes more apparent as the work is undertaken in the southern part of the quarantined area, and it is now generally recognized that infested horses and mules are frequently responsible for the spread of ticks and the resulting delays in completing tick eradication. The bureau has for several years advocated that horses and mules in tick-eradication areas if infested with, or exposed to, ticks receive the same consideration as cattle. This policy is now being followed and required by State regulation throughout the tick-eradication area.

Under the supervision of the cooperating forces 19,295,422 inspections or dippings of cattle were conducted and more than 15,500 dipping vats were used in these official dippings.

RESULTS FOLLOWING THE YEAR'S ACTIVITIES

During the fiscal year the following areas were released from Federal quarantine as a result of the tick-eradication work: Three counties in Alabama; 1 county and the remainder of 1 county in Arkansas; 8 counties in Florida; 2 parishes and part of 1 parish in Louisiana; 1 county and the remainder of 3 counties in Oklahoma, and 8 counties in Texas. It was not necessary to requarantine any area in the United States during the year.

The release of territory in Oklahoma placed all of that State above the tick-quarantine line, thus making it the ninth of the original 15 tick-infested States to reach this goal.

The eight Florida counties, released during the year from Federal quarantine, are adjacent to the Georgia-Florida line. The eradication of ticks from this area and the fact that the systematic dipping of cattle to eliminate ticks is now being conducted in Nassau County, the only remaining ticky Florida county touching the southern boundary of Georgia, makes possible the early elimination of the quarantine line fence which has been the cause of much controversy. This barrier consists of two 5-wire fences, 15 feet apart, extending for a distance of about 150 miles along the Georgia-Florida border. The fence was primarily financed by counties of southern Georgia, and later taken over and maintained by the State, so that Georgia might be relieved from the migrations of ticky cattle from Florida. It is generally believed that this fence, with cattle guards at the road crossings, supplemented by line riders to see that the fence was in good repair, has been well worth its cost.

Table 27 shows the progress made in tick eradication since its beginning in 1906, and gives the status of the work at the close of the fiscal year 1929.

TABLE 27.—*Tick-eradication results July 1, 1906, to June 30, 1929*

States	Counties quarantined		Counties released to June 30, 1929	Released counties tick-free on—			
	July 1, 1906	June 30, 1929		Nov. 1, 1925	Nov. 1, 1926	Nov. 1, 1927	Nov. 1, 1928
Alabama	67	1	66	49	49	57	59
Arkansas	75	20	55	31	41	44	45
California	15	0	15	15	15	15	15
Florida	67	41	26	7	12	14	22
Georgia	158	0	158	149	151	153	154
Kentucky	2	0	2	2	2	2	2
Louisiana	64	41	23	4	11	4	8
Mississippi	82	23	59	47	47	46	45
Missouri	4	0	4	4	4	4	4
North Carolina	73	0	73	65	73	71	73
Oklahoma	61	0	61	52	55	54	54
South Carolina	46	0	46	40	40	44	46
Tennessee	42	0	42	42	42	42	42
Texas	198	72	126	69	72	77	79
Virginia	31	0	31	25	27	26	29
Total	985	198	787	601	641	653	677

MOVEMENTS FROM QUARANTINED AREAS

The interstate shipment of ticky cattle from the quarantined areas as "southern cattle" for immediate slaughter was discontinued, effective May 1, 1928, under the provisions of the act of Congress, approved June 28, 1926, commonly referred to as the Crisp bill. Cattle owners of the quarantined area have readily adjusted the marketing of their cattle to the new requirements, and are finding the unrestricted market for tick-free cattle a profitable one.

Owing to these restrictions the requests for inspection and certification authorizing the interstate shipment of cattle from the quarantined area nearly doubled during the year. In preparing cattle of the quarantined area for such shipment 320,444 head were inspected, or dipped and inspected, in the field, for which 4,968 certificates were issued authorizing their movement as noninfectious. Horses and mules to the number of 8,420 were also inspected in the quarantined area and 609 certificates issued authorizing their shipment from the area.

MOTION PICTURES HELP TICK ERADICATION

The use of the motion picture continues to prove of value as a means of demonstrating the method necessary in successfully conducting tick eradication and the benefits that may be expected to follow that work. With the two portable motion-picture outfits, audiences aggregating 63,601 persons were reached at 486 exhibitions given in the rural districts of the tick-infested sections of Arkansas, Florida, Mississippi, and Texas.

TUBERCULOSIS ERADICATION DIVISION

The work of tuberculosis eradication, in cooperation with the various States, counties, and livestock owners, made substantial progress during the year. This work on the part of the bureau was directed by A. E. Wight, chief of the tuberculosis eradication division.

The year's activities consisted largely in the tuberculin testing of cattle under the area plan, about 400,000 more tuberculin tests being applied than in any preceding year. The percentage of reactors found dropped from 2.3 per cent for the fiscal year 1928 to 1.8 per cent. This decrease indicates noteworthy progress in eradicating the disease.

The bureau's force engaged in tuberculosis eradication averaged 204 veterinarians, who were under the supervision of inspectors in charge of 44 field stations. The respective States had under the jurisdiction of their livestock officials an average of 358 veterinarians, a small number of whom were employed by municipalities. The respective counties cooperating with the officials of the States and the bureau employed an average of 327 veterinary inspectors on full time. Thus there was a total of 889 veterinarians engaged in the work regularly throughout the year, which is a decrease of approximately 35 full-time employees compared with the preceding year.

The Federal appropriation was $5,744,710, of which $1,123,580 was allotted for operating expenses and $4,621,130 for paying indemnity to owners for cattle condemned as a result of the test. These figures indicate a net decrease of approximately $220,000 for all purposes compared with 1928. The combined State and county appropriations were more than $13,500,000, an increase of about $500,000 over the preceding year.

The plans for the work now include (1) the eradication of tuberculosis under the accredited-herd plan; (2) the area plan; (3) the eradication of tuberculosis from swine; (4) investigations relative to interstate shipments; (5) tuberculosis in fowls; and (6) the control and eradication of Johne's disease (paratuberculosis).

A number of herds of cattle in several States were tested during the year by the use of either avian tuberculin or johnin, and indemnity was paid for animals which reacted and were slaughtered. The tests conducted indicate that much more work must be done to develop a standardized diagnostic agent before the johnin test will become entirely practicable for field purposes.

During the fiscal year 1929 all the remaining counties in the States of North Carolina and Maine were designated as modified accredited area, thus placing these two entire States in that status.

Important State legislation was enacted during the year, and appropriations by the States for tuberculosis-eradication work were sufficiently large to make it possible for most of the States to proceed in the campaign in an effective manner. Legislation favorable for the early completion of the work has been enacted in several States. There was also a tendency on the part of State legislatures to increase the amount of State indemnity. The Federal indemnity was increased from $25 to $35 per head as a maximum for grade cattle and from $50 to $70 per head as a maximum for purebreds, effective February 19, 1929,

ACCREDITED TUBERCULOSIS-FREE HERDS

Although major attention was given to the area project, tuberculin testing under the accredited-herd plan showed marked progress in practically all States. At the conclusion of the year there were listed, as fully accredited, 170,995 herds, an increase of 1,639 over the previous year. Comparative figures showing progress are given in Table 28.

TABLE 28.—*Progress of tuberculin testing under accredited-herd and area plans, 1917–1929*

Year ended June 30—	Cattle tested					Modified accredited counties	Herds accredited [1]	Herds passed one test [1]	Herds under supervision [1]
	Accredited herd plan	Area plan	Total	Reactors found	Percentage of reactors				
	Number	*Number*	*Number*	*Number*		*Number*	*Number*	*Number*	*Number*
1917	20,101	----------	20,101	645	3.2	----------	----------	----------	----------
1918	134,143	----------	134,143	6,544	4.9	----------	204	883	----------
1919	329,878	----------	329,878	13,528	4.1	----------	578	5,652	----------
1920	700,670	----------	700,670	28,709	4.1	----------	2,588	10,064	----------
1921	1,366,358	----------	1,366,358	53,768	3.9	----------	4,831	33,215	71,806
1922	1,722,209	[2] 662,027	2,384,236	82,569	3.5	----------	8,015	111,719	140,376
1923	1,695,662	1,765,187	3,460,849	113,844	3.3	----------	12,310	150,748	187,915
1924	1,865,863	3,446,501	5,312,364	171,559	3.2	38	19,747	216,737	305,809
1925	2,008,526	4,991,502	7,000,028	214,491	3.1	51	24,110	392,740	414,620
1926	1,989,048	6,661,732	8,650,780	323,084	3.7	109	24.009	382,674	435,840
1927	2,522,791	7,177,385	9,700,176	285,361	2.9	149	34,084	229,086	261.148
1928	2,589,844	8,691,646	11,281,490	262,113	2.3	180	38,880	427,595	473,218
1929	2,853,633	8,830,087	11,683,720	206,764	1.8	213	1,639	249,420	281,323
Total	19,798,726	42,226,067	62,024,793	1,762,979	2.8	[3] 740	170,995	2,210,533	2,572,055

[1] The figures in these columns represent net increases at the close of each year.
[2] Testing during six months.
[3] Not including parts of 3 counties and 30 towns.

The total numbers of herds and cattle under supervision at the end of the year were 2,572,055 and 23,947,547, respectively. On the basis of the latest census figures of cattle on farms, this total indicates approximately 39 per cent of the entire cattle population of the United States as

being under supervision for the eradication of tuberculosis. It is also noteworthy that 20 States report more than 50 per cent of their cattle population as being under such supervision. These States are led by North Carolina and Maine, in which all the cattle have been tuberculin tested and the entire State listed as a modified accredited area. This designation signifies that the extent of tuberculosis among cattle does not exceed one-half of 1 per cent. As an indication of the continued interest in the work throughout the United States, there was at the end of the year a waiting list of more than 257,744 herds containing 2,320,488 cattle.

Marked increase in the herds under supervision as the result of accredited-herd and area work necessitated the tuberculin testing of 1,030,679 herds, including 11,683,720 cattle. These figures include cattle tested for interstate shipment. The testing resulted in the removal of 206,764 reactors, or 1.8 per cent, which is the smallest percentage since the beginning of the work. It is noteworthy, as shown in Table 28, that since 1917 more than 1,760,000 reactors have been removed from the cattle herds of the Nation without serious economic disturbance or creating any shortage of the necessary milk supply.

Accredited practicing veterinarians continued to cooperate, their work showing an increase of more than 26 per cent over 1928 in the volume of testing conducted. This class of veterinarians tested during the year 95,799 herds, containing more than 1,444,236 cattle, at the expense of the livestock owners.

ERADICATION OF TUBERCULOSIS FROM AREAS

The area work has continued to grow, indicating both the efficiency and popularity of this plan. Approximately 76 per cent of the total cattle tested in the work of eradication were tested under the area plan. At the conclusion of the fiscal year 1,200 counties and the District of Columbia had engaged in area work. This is an increase of 81 counties, or approximately 7 per cent, over the number for the preceding year. County expenditures for the furtherance of area work were approximately $1,300,000.

At the conclusion of the year the modified accredited area included 740 counties, 30 towns, and parts of three other counties. This is in comparison with 527 such areas at the end of 1928. Field reports indicate that at the completion of the year 24.1 per cent of the total counties in the United States were in the modified accredited class, and that including the modified counties 39.1 per cent of the entire number of counties in the United States were engaged in eradicating the disease from their livestock. Table 29 indicates the status of area work on June 30, 1929.

TABLE 29.—*Status of tuberculosis eradication from county areas at close of fiscal year 1929*

State	Counties completing one or more tests of all cattle [1]	Counties intensively engaged in testing	Total counties engaged [1]	Modified accredited areas	Cattle tested during year
Arizona	0	2	2	0	39,061
Arkansas	1	0	1	1	17,116
California	5	2	7	2	80,954
Colorado	0	1	1	0	7,857
Connecticut	0	4	4	0	36,897
Delaware	1	0	1	0	----------
District of Columbia	1	0	1	0	631
Florida	2	0	2	0	----------
Georgia	14	3	17	10	39,371
Idaho	27	12	39	27	79,237
Illinois	43	33	76	43	1,058,614
Indiana	65	13	78	64	320,900
Iowa	54	10	64	44	735,514
Kansas	41	6	47	41	170,425
Kentucky	51	10	61	18	74,672
Maine	16	0	16	16	57,099
Maryland	7	9	16	1	112,077
Massachusetts	1	1	2	1	12,522
Michigan	70	6	76	65	730,099
Minnesota	38	0	38	24	876,105
Mississippi	6	1	7	5	25,506

[1] Including District of Columbia.

TABLE 29.—*Status of tuberculosis eradication from county areas at close of fiscal year 1929*—Continued

State	Counties completing one or more tests of all cattle	Counties intensively engaged in testing	Total counties engaged	Modified accredited areas	Cattle tested during year
Missouri	9	4	13	9	82,256
Montana	[2] 11	[2] 2	14	[2] 11	33,737
Nebraska	39	4	43	37	368,346
Nevada	0	12	12	0	28,568
New Hampshire	1	4	5	1	5,887
New Mexico	0	13	13	0	12,709
New York	19	29	48	8	556,055
North Carolina	100	0	100	100	22,025
North Dakota	30	9	39	26	161,267
Ohio	44	15	59	35	393,066
Oregon	13	14	27	7	124,157
Pennsylvania	22	35	57	20	452,472
South Carolina	12	2	14	12	40,981
South Dakota	5	0	5	5	49,255
Tennessee	11	1	12	11	93,553
Utah	2	22	24	1	99,051
Vermont	[3]	8	8	[3]	43,594
Virginia	26	7	33	25	92,861
Washington	[4] 12	[4] 15	29	[4] 9	189,191
West Virginia	20	5	25	18	82,442
Wisconsin	60	5	65	43	1,423,957
Total	[5] 879	[5] 319	1,201	[5] 740	8,830,087

[2] Not including part of 1 county.
[3] Not including 30 towns.
[4] Not including part of 2 counties.
[5] Not including part of 3 counties and 30 towns.

STATISTICS OF SLAUGHTER AND INDEMNITY

Continued attention was given to the marketing of reactor cattle. The large number of such animals thrown on to the markets makes this an important phase of the cooperative work. It is noteworthy, as indicated by the average salvage per head, shown in Table 30, that these efforts have been fruitful, though aided by a high average market price for beef cattle throughout the year. Visits were made by State and bureau workers to public stockyards, packing houses, commission agencies, and others wherever it was suspected that better prices might be obtained. The average salvage for 1929, as will be noted by Table 30, was $46.01, an increase of $6 over the amount during the preceding year.

TABLE 30.—*Cattle slaughtered, appraised value, indemnity allowed, and salvage realized in work of tuberculosis eradication, fiscal year 1929*

State	Cattle slaughtered	Average appraisal per head	State indemnity	Federal indemnity	Average State indemnity per head	Average Federal indemnity per head	Average salvage per head
	Number	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Arizona	546	131.84	13,977.68	13,977.68	25.60	25.60	31.12
Colorado	390	124.55	8,671.98	8,666.98	22.24	22.22	50.45
Connecticut	1,243	127.72	68,303.34	28,769.49	54.95	23.15	48.66
Delaware	1,225	86.72	31,253.27	21,356.94	25.51	17.43	34.37
Florida	95	46.03	2,160.93	1,045.62	22.75	11.01	9.96
Georgia	37	69.20	627.67	627.67	16.96	16.96	17.15
Hawaii	194	194.12	10,550.00	5,272.39	54.38	27.18	58.70
Idaho	84	63.61	946.53	946.53	11.27	11.27	29.31
Illinois	14,788	120.38	297,187.32	297,187.32	20.10	20.10	55.33
Indiana	1,417	121.51	35,339.89	32,210.52	24.94	22.73	45.50
Iowa	10,406	123.25	242,293.78	227,320.41	23.28	21.85	52.45
Kansas	791	114.62	16,116.39	14,703.61	20.37	18.59	46.38
Kentucky	208	89.67	6,969.99	3,843.95	33.51	18.48	31.84
Louisiana	96	49.48	1,288.01	888.01	13.42	9.25	22.37
Maine [1]	397	100.89	27,496.45	8,422.84	69.26	21.22	26.55
Maryland	5,814	78.88	84,434.36	84,434.36	14.52	14.52	35.16

[1] Salvage paid to State.

TABLE 30.—*Cattle slaughtered, appraised value, indemnity allowed, and salvage realized in work of tuberculosis eradication, fiscal year 1929*—Continued

State	Cattle slaughtered	Average appraisal per head	State indemnity	Federal indemnity	Average State indemnity per head	Average Federal indemnity per head	Average salvage per head
	Number	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Massachusetts	2,663	167.91	107,090.49	78,482.74	40.21	29.47	42.00
Michigan	3,625	154.48	119,092.50	99,554.45	32.85	27.46	50.54
Minnesota	9,441	81.24	106,669.52	90,924.06	11.30	9.63	46.31
Mississippi	23	109.48	554.11	554.11	24.09	24.09	20.14
Missouri	108	111.57	2,273.10	2,273.10	21.05	21.05	47.68
Montana [1]	90	53.26	3,608.74	1,239.19	40.10	13.77	16.37
Nebraska	1,847	120.52	26,260.45	26,260.45	14.22	14.22	54.00
Nevada	127	67.63	603.02	511.23	4.75	4.03	46.58
New Hampshire	2,459	87.38	81,375.88	41,262.08	33.09	16.78	35.48
New Jersey	3,695	134.70	109,557.92	89,955.61	29.65	24.35	47.91
New Mexico	40	69.52	420.87	403.94	10.52	10.10	37.87
New York	30,114	133.06	1,947,959.17	687,798.79	64.69	22.84	43.55
North Carolina	82	135.49	1,930.67	1,930.67	23.54	23.54	41.75
North Dakota	1,483	66.86	11,786.18	11,786.18	7.95	7.95	43.40
Ohio	7,884	149.41	216,278.13	208,637.64	27.43	26.46	51.22
Oklahoma	185	127.65	4,187.78	3,916.08	22.64	21.17	39.19
Oregon	364	128.52	4,151.36	4,151.36	11.40	11.40	39.99
Pennsylvania	18,568	153.45	751,048.15	496,512.84	40.45	26.74	45.12
Rhode Island	235	122.93	12,497.50	5,381.53	53.18	22.90	40.39
South Carolina	74	76.89	1,445.48	1,445.46	19.53	19.53	19.65
South Dakota	879	105.24	15,164.76	15,164.76	17.25	17.25	49.85
Tennessee	180	102.76	4,498.33	3,967.81	24.99	22.04	24.43
Texas	115	174.00	3,546.87	3,546.87	30.84	30.84	41.84
Utah	848	114.56	18,756.27	18,756.27	22.12	22.12	44.37
Vermont	3,791	77.93	55,127.52	55,127.52	14.54	14.54	19.88
Virginia	832	135.52	20,699.55	20,546.53	24.88	24.70	37.17
Washington	3,133	141.80	79,199.25	79,199.25	25.28	25.28	49.80
West Virginia	467	89.96	12,870.44	7,060.74	27.56	15.12	26.07
Wisconsin	9,109	135.59	168,418.87	168,418.87	18.49	18.49	52.41
Wyoming	2	175.00	62.50	62.50	31.25	31.25	
Total	140,194	125.76	4,734,752.97	2,974,506.95	33.77	21.22	46.01

[1] Salvage paid to State.

ERADICATION OF TUBERCULOSIS FROM SWINE AND FOWLS

Many of the packers continued to pay voluntarily the 10 cents per hundredweight premium on hogs originating in modified accredited areas, provided they were properly identified by registered tattoo marks and were free from tuberculosis on post-mortem examination.

The eradication work in poultry included giving poultry owners information on the need of proper sanitation, maintenance of flocks under the best conditions of poultry husbandry, and the use of the tuberculin test when necessary for the diagnosis of the disease. The survey of farm flocks in connection with the testing of cattle, begun several years ago, was continued. During the year 165,239 flocks, containing approximately 16,763,700 fowls, in 25 States, were inspected. Nearly 11,000 of these flocks were found to be infected with tuberculosis, as indicated by cases of the disease in the flocks. These inspections were made by veterinarians engaged in the testing of cattle and with very little additional cost to the department.

REGULATION OF INTERSTATE MOVEMENT OF CATTLE

Under the provisions of regulation 7, Bureau of Animal Industry Order 309, the approved veterinary practitioners throughout the 48 States continue to conduct most of the tuberculin testing for interstate shipments of cattle. There were on the list of approved veterinarians on June 30, 1929, more than 9,400 veterinary practitioners, who, under a cooperative plan, are approved by the State and Federal livestock sanitary officials. These men tested for interstate shipment 40,920 lots containing 464,874 cattle, of which 0.4 per cent reacted. The number tested is an increase of 59,927 cattle over that reported during 1928.

In an effort to assist livestock owners in facilitating the interstate movement of cattle there were tested, under the provisions of the regulations at public stockyards, by bureau inspectors, 45,497 cattle, of which 1.2 per cent

reacted. These figures of testing by bureau and approved veterinarians are included in the total testing for the year as reported in Table 28.

Interstate transportation of reactor cattle, also under the provisions of regulation 7, for the purpose of immediate slaughter was continued under the permit system. Permits were issued covering the movement of 33,857 such cattle. The regulations permit the return of breeding cattle to the point of origin when they have been moved interstate and have reacted after delivery. It is noteworthy that no permits were issued covering the return of such animals. Permits were issued covering the interstate movement of 26,613 bull calves under 6 months of age, subject to castration at destination.

TUBERCULIN TESTING

Table 31 shows the relative use of the various methods of tuberculin testing as reported. The total varies somewhat from the total tests for the year in Table 28 because some of the reports did not state the method of testing.

TABLE 31.—*Relative use of testing methods, fiscal year 1929*

Test employed	Cattle tested	Reactors found	Percentage of reactors
	Number	*Number*	*Per cent*
Intradermic alone	9,914,332	148,278	1.5
Subcutaneous alone	1,108	23	2.1
Ophthalmic alone	160	3	1.9
Combination of tests	1,178,808	56,842	4.8
Total	11,094,408	205,146	1.8

Of the cattle reported as tested in Table 28, about 19.6 per cent were tested by bureau inspectors and about 80.4 per cent by State, municipal, and accredited practicing veterinarians. Considerable pressure was brought to bear on field offices to insure a sufficient amount of field supervision to maintain the tuberculin test at its highest possible efficiency. With approximately 900 veterinarians engaged daily in the work it can be seen that this was necessary in order that the highest possible standards, established in the past, might be maintained. Attention was again given the so-called no-visible-lesion cases noted on postmortem examination of slaughtered reacting cattle. More than half of such cases were found to have originated in herds known to harbor infection.

This supervision of field veterinarians was also maintained so as to reduce the average cost of testing per head. The standard of professional service rendered by the field veterinarians continued to be of a high degree of excellence.

CONFERENCES AND PUBLICITY ON TUBERCULOSIS ERADICATION

The Tenth Annual Eastern States Conference on Tuberculosis was held at Springfield, Mass., June 18, 19, and 20. This conference was well attended, and continued to be an influential factor in the eradication work. Another conference was held in the mid-western States at Sioux Falls, S. Dak., June 5 and 6, and still another in the Southwestern States at Fort Worth, Tex., January 22 and 23. All of these conferences made it possible for field workers to gain valuable information, and the general publicity given the conferences was of much benefit to the work. These conferences were also attended by many others who are interested in the livestock industry, as well as those interested in public health.

DIVISION OF VIRUS-SERUM CONTROL

The activities of this division, consisting of the administrative and regulatory work under the virus-serum-toxin act of 1913, were continued under the direction of D. I. Skidmore, chief. The work consists chiefly in the issuance of licenses to establishments producing veterinary biological products intended for sale in interstate commerce, the inspection of sanitary conditions and methods of production in the establishments, the supervision of the production and testing of biologics, and the certification of products for export. It also includes the issuance of permits to import biologics from abroad, together with the inspection of shipments of biologics at ports of entry.

WORK AT LICENSED ESTABLISHMENTS

Supervision was exercised over 88 licensed establishments in 61 cities and towns in 20 States, as compared with 89 establishments in 60 cities and towns during the preceding fiscal year. At the close of the year 49 establishments were engaged in producing only anti-hog-cholera serum and hog-cholera virus, 33 were producing other biologics only, and 6 were producing both

classes of products. Inspectors of the bureau supervised the production and testing of anti-hog-cholera serum and hog-cholera virus, as well as conducting tests to determine whether these products were preserved properly. They also made periodical visits of inspection to establishments producing other biologics. Samples of biologics, as well as cultures of organisms used in their production, were collected for examination at the time of many of these visits.

During the year an average of 91 inspectors was maintained in the field. These inspectors examined and admitted to licensed establishments 477,142 hogs and 1,212 calves. Of these, 162 hogs were rejected at the time they were offered for admission and 24,173 hogs were rejected after admission because of conditions which made them unsuitable for the production or testing of biologics. The inspectors also supervised 6,285 potency and 5,004 purity tests of anti-hog-cholera serum.

Inspectors of the division collected 201 samples of biologics or materials intended for use in preparing them. On examination in the laboratories of the bureau, 154 of these samples were found to be satisfactory and 47 unsatisfactory or contaminated. One hundred and sixty strains of organisms intended for use in the preparation of biologics by establishments were collected and submitted for laboratory examination. Of these, 106 were found to be satisfactory and 54 unsatisfactory or contaminated.

OUTPUT OF BIOLOGIC PRODUCTS

During the year licensed establishments produced 979,612,105 c. c. of anti-hog-cholera serum, of which 245,390,294 c. c. (25.05 per cent) was defibrinated-blood serum and 734,221,811 c. c. (74.95 per cent) was clarified serum. The quantity of simultaneous hog-cholera virus produced by these establishments was 63,550,125 c. c., while their production of hyperimmunizing virus amounted to 210,025,522 c. c. and of inoculating virus 931,800 c. c., so that the total quantity of virus produced was 274,507,447 c. c.

The quantity of other biologics produced by licensed establishments aggregated 35,485,473 doses, classified as follows: Aggressins, 11,264,216; antisera and sera, 1,752,439; avian tuberculin, etc., 490,764; bacterins, 11,575,475; mallein, 98,945; pullorin, 1,238,555; tuberculin, 2,693,393; vaccines and viruses, 6,371,686.

PRODUCTS REJECTED

The quantity of anti-hog-cholera serum destroyed as unfit for use in the treatment of animals aggregated 7,147,662 c. c. Of this quantity 4,784,982 c. c. were derived from animals affected with diseases such as tuberculosis, pneumonia, and septicemia, and the remaining 2,362,680 c. c. were destroyed because of contamination in the process of manufacture or on account of other conditions which rendered the product unfit for use.

The total quantity of simultaneous virus destroyed aggregated 1,807,816 c. c., of which 793,925 c. c. were destroyed on account of being derived from diseased animals, and 1,013,891 c. c. because of contamination or other undesirable conditions.

The total quantity of hyperimmunizing virus destroyed was 6,741,972 c. c., of which 6,208,465 c. c. was destroyed on account of disease and 533,507 c. c. on account of contamination or similar conditions.

EXPORTS AND IMPORTS OF BIOLOGIC PRODUCTS

In cooperation with the Treasury and Post Office Departments and the Food, Drug, and Insecticide Administration the bureau exercises control over the importation of veterinary biologics. At the close of the year two permits to import such products were outstanding. Bureau inspectors examine at the port of entry shipments of biologics offered for importation, and products not eligible for importation are either denied entry or destroyed. During the year 489 certificates to accompany shipments to 28 foreign countries were issued by bureau inspectors. Although certificates are not required in all cases, the total of all export shipments reported to the bureau aggregated 20,506,060 c. c. Of this quantity anti-hog-cholera serum constituted the major portion, or 17,802,645 c. c.

ZOOLOGICAL DIVISION

The scientific investigation of animal parasites and the practical application of control measures along lines of treatment and prevention were continued under the direction of Maurice C. Hall, chief.

PARASITES OF POULTRY

Previous lines of work on worm parasites of poultry were continued, and investigations of protozoan para-

sites, suspended for several years, were renewed.

NEMATODES

Investigations of nematode parasites developed the fact that grasshoppers, never before shown to act as intermediate hosts of nematodes of vertebrates, are actually important intermediate hosts, conveying such parasites as the proventricular worm, *Tetrameres americana*, of the chicken and other gallinaceous birds, the gizzard worm, *Cheilospirura hamulosa*, of the chicken, the gizzard worm, *Cheilospirura spinosa*, of ruffed grouse and bobwhite quail, and the gizzard worm, *Acuaria anthuris*, of crows. Crickets serve also as intermediate hosts for the crow gizzard worm. In view of the fact that grasshoppers are important as bird food and are so commonly eaten by chickens and turkeys, it is evident that these insects must be given attention in any attempt to raise poultry free from worm parasites. Certain dung beetles, *Copris minutus* and *Phanaeus carnifex*, were found to be the intermediate hosts of the crop spirurid, *Gongylonema inglucicola*, of poultry. The life history of any one of these five nematodes had not been previously ascertained.

A new nematode of the genus Strongyloides, a genus not previously known as parasitic in birds, was found in chickens. All stages of its life history were experimentally developed; chickens and quail were experimentally infected; and clinical and pathological observations were made.

In cooperation with the Bureau of Biological Survey, studies of parasitic nematodes of quail were continued. Sixteen nematode species have been identified from this host, all but one of which were previously unknown from quail. Experiments on life histories and pathology were conducted, and cross transmission from game birds to poultry and poultry to game birds has been accomplished in a number of instances. In these investigations it was found that in southern Georgia and northern Florida certain wild birds, especially the loggerhead shrike, were heavily infested with encysted larval nematodes which, when fed to other birds, or to mammals or reptiles, reencysted as third-stage larvae, but did not undergo further development. A search for the intermediate hosts of the larvae in earlier stages developed the fact that certain dung beetles, *Phanaeus carnifex* and *Canthon laevis*, which are eaten in large numbers by shrikes, were the hosts in question. The primary host of the adult worm was found to be the pig, and the worm was identified as one of the swine stomach worms, *Physocephalus sexalatus*. A small section of the intestine of a shrike heavily infested with the larvae was fed to a pig with the resultant development of approximately 800 of these worms in the pig.

CESTODES

Continued investigation of the life histories of poultry tapeworms has added a number of new intermediate hosts and cleared up some life histories. In addition to *Aphodius granarius*, the beetle reported last year as an intermediate host of *Hymenolepis carioca*, other beetles have been found to serve as intermediate hosts. Using *A. granarius* as the intermediate host, this chicken tapeworm was transferred to the bobwhite quail.

In addition to the wood snail, *Zonitoides arborea*, reported last year as an intermediate host of *Davainea proglottina*, other snails have been found to serve as intermediate hosts. The hosts previously known for this tapeworm were two species of slugs.

A study of the life history of *Raillietina cesticillus* demonstrated the fact that this tapeworm will develop in certain beetles. Variations have been noted in the time of development in the primary and secondary hosts. Previous work by investigators elsewhere had indicated that the house fly was a carrier of this worm, but the evidence for this is incomplete.

In the spring of 1928, investigations on protozoan parasites of poultry were renewed. Coccidiosis is being given special attention as regards the strains present and their effects. Experimental treatments with carbon tetrachloride in repeated doses have given apparently good results in the control of coccidiosis as such, but the treatment apparently results in stunting the growth of young chickens. Experiments in the administration of tomato pulp to chickens affected with clinical coccidiosis resulted in a marked reduction in the number of coccidia, a rapid recovery from diarrhea, and clinical recovery.

In connection with cooperative work with the Bureau of Biological Survey, malarial infection has been found in the bobwhite quail in Georgia.

PARASITES OF SWINE

The essential facts concerning the life history of the swine kidney worm have been ascertained and are briefly as follows. Infestation results from the ingestion of infective larvæ; the latter do not penetrate the unbroken skin but penetrate the broken skin or the mucosa. The larvæ reach the liver by way of the portal vein and its branches, penetrate the hepatic tissue, gradually make their way to the surface of the liver, and finally perforate the liver capsule. The larvæ also reach the lungs and other organs and tissues to which they are carried by the circulation, but the path which apparently leads to the successful completion of their life cycle is from the liver to the peritoneal cavity and thence to the perirenal fat, where they become inclosed in pus pockets which communicate with the ureter by fistulous tracts. Evidence has also been obtained which indicates that the larvæ perforate the walls of the portal vein and come to lie in the periportal tissue, which increases in size considerably. Significant and profound lesions associated with the migrations of the worms through the cavities and tissues of the body have been noted. In case of experimental kidney-worm infestation, growth of pigs was arrested and in cases of heavy infestation there was a severe emaciation followed by death. Studies on the eggs and larvæ of these parasites showed that they offer comparatively little resistance to drying and to low temperatures.

An intestinal parasite of swine, Strongyloides, which has been charged with producing at times symptoms of gastroenteritis, emaciation, debility, and arrested growth, and even causing death, has been found to be of relatively common occurrence in swine at Bethesda, Md., and Moultrie, Ga. A study of these parasites showed them to be distinct from the forms described from Europe and other parts of the world. Investigations have definitely shown that the swine Strongyloides occurring in the United States is distinct from that occurring in sheep.

Studies of nodular worms occurring in swine in the vicinity of Moultrie, Ga., disclosed the presence of two new species. In view of dissenting opinions in the literature on parasitology with reference to the occurrence of larval nodular worms in the walls of the large intestine of swine, this subject has been reinvestigated, and it was definitely shown that larvæ of certain nodular worms occur in small, connective-tissue cysts which are located in the wall of the cecum. As the larvæ increase in size they break out of the cysts and lie free in the nodules which increase in size as the worms grow older. The larvæ gradually work their way to the surface of the mucosa and the nodules become surrounded by a reddened zone with a definite necrotic center in which the worms lie. Bacteria apparently gain entrance into the nodules and set up a severe inflammatory reaction and may cause a marked ulceration.

A continuation of the swine-sanitation work in Georgia, with a view to developing a system adapted to southern conditions, gave the following results: Average weight of sanitation pigs, at marketing, 178 pounds, of check pigs, 189 pounds, or 11 pounds in favor of check pigs; average age of sanitation pigs at time of marketing, 9 months and 4 days, of check pigs, 10 months and 17 days, or 43 days in favor of sanitation pigs; pigs saved of those farrowed in sanitation herds, 75.1 per cent, in check herds, 66.7 per cent; normal livers in sanitation pigs at time of slaughter, 24.2 per cent, of check pigs, 6.3 per cent; freedom from carcass infestation with kidney worm among sanitation pigs, 65.4 per cent, among check pigs, 51.7 per cent. While these results indicate a net gain from sanitation in general, the difference is more marked when the system is more closely followed; observance of sanitary measures ranged from excellent to fair.

PARASITES OF RUMINANTS

NEMATODES

An experiment was carried out at McNeill, Miss., to determine the possibility of eradicating stomach worms and other nematode parasites of sheep. The studies included the use of various treatments and control measures for infestations with these worms, especially in connection with treatments every two weeks in place of every three weeks, the latter procedure having given control but not eradication. The sheep were native wethers and each group was placed on a pasture of 1.1 acres of mixed Bermuda, Lespedeza, and other suitable grasses. All sheep which died were examined postmortem for worms and periodical fecal examinations were made to determine the relative extent of parasitism with nematodes.

Several of the control measures used were effective against the parasites. The sheep gained in weight and in wool production and the indications are that eradication of stomach worms and related nematodes of the stomach and intestines is feasible on heavily stocked pastures under conditions naturally favorable to these parasites.

The occurrence of *Ostertagia ostertagi* in nodules in the stomach of sheep was reported from the United States for the first time. Nodules in the stomach of sheep caused by *Trichostrongylus extenuatus* were noted and a study of nodules in the duodenum of sheep from Oregon revealed the presence in them of a nematode, *Ostertagia circumcincta*, which was not generally regarded as a nodule producer.

TREMATODES

An investigation of control measures for liver flukes was begun in an area in California in cooperation with the State university and experiment station, the State department of agriculture, and other organizations. Control measures used included the treatment of infested sheep with carbon tetrachloride, the destruction of snails on infested pastures by means of copper sulphate, and the draining, filling in, or fencing off of wet areas not suitable for snail control by means of copper sulphate. The sheepmen cooperated enthusiastically and the results of the first year's work were very satisfactory. About 50,000 sheep were treated for flukes and on many ranches snail destruction was well carried out.

As the snail host of the common sheep liver-fluke in California was not known when the control work was begun, snail destruction was directed against amphibious and aquatic snails in general. In the spring of 1929 an investigator, detailed to ascertain the snail host in this State, found it to be *Galba bulimoides*, the snail which had just previously been found to be the snail host in Oregon by workers at the Oregon experiment station. The same investigator found the snail host in Louisiana to be *G. b. techella*. In both cases the entire life history was ascertained experimentally.

In three flocks there were losses of 2 to 6 per cent following treatments with carbon tetrachloride. In all cases the flocks had been treated twice without loss while on pasture, and losses occurred when the third treatment followed a change of feed, in two cases to bur clover and barley and in one case to alfalfa pasture. The significance of losses from treatment following a change of feed is being investigated. In many cases oyster-shell flour is being fed to sheep to offset the possibility that carbon tetrachloride might cause injury by virtue of a deficiency in ionized-blood calcium. On heavily infested pastures it has been found necessary to treat every two weeks during the season when flukes are prevalent.

PROTOZOA

Investigations at Jeanerette, La., on anaplasmosis developed the fact that this disease in Louisiana is identical with anaplasmosis in other parts of the world. In connection with this, blood smears from cases of anaplasmosis and theileriosis in Africa and South America were supplied by competent investigators in those countries and compared with smears from Louisiana cases. The "marginal points" and the clinical symptoms, including fever, severe anemia, icterus, and profound depression, are identical. It was found experimentally that the disease as it occurs in pure infections, unmixed with piroplasmosis, in areas free from the Texas-fever tick, is identical with the disease as it occurs in conjunction with piroplasmosis in ticky areas in Texas.

Seed ticks from females of the Texas-fever tick, *Boophilus annulatus*, engorged on cases of pure anaplasmosis, conveyed the disease to a clean animal in one out of four cases, the first experimental transmission of the sort in this country. In a similar experiment with *Amblyomma americanum* the seed ticks did not transmit the disease.

Other experiments showed the following: Anaplasmosis is inoculable from animal to animal by blood transfer; an animal recovered from the disease is relatively immune to a second inoculation, though the duration of immunity was not ascertained; an animal recovered from the disease remains a carrier for at least three years; blood from an animal with anaplasmosis can be injected into a sheep without producing any visible effects, but when blood from the sheep is withdrawn 30 days after the injection and injected into a susceptible animal it produces anaplasmosis; and the disease can not be transmitted to rabbits or guinea pigs by blood inoculation.

INSECTS

An extensive investigation of ox-warble control was undertaken in cooperation with the Bureau of Entomology, that bureau giving attention to the entomological aspects of the problem and the Bureau of Animal Industry to the veterinary side. The latter work was carried out in two areas, Knox County, Ill., and Prowers County, Colo. The first embraced an area of approximately 150 square miles, mostly a range-cattle area with only one species of ox warble, *Hypoderma lineatum*, present. The second embraced an area of approximately 200 square miles, a general farming area with dairy and feeder cattle, and with both *H. lineatum* and *H. bovis* present. The lines of investigation included: The extraction and destruction of grubs, the treatment of cattle with insecticides to destroy grubs, and applications of various substances to the hair coat to destroy the viability of warble-fly eggs.

In the extraction of grubs by hand, small, alligator forceps were finally selected as most satisfactory. Experience showed that unless special precautions were taken, bacterial infection was transferred from one lesion to another and from one animal to another. To prevent this, each day's work was begun with cleaned and sterilized instruments and as soon as the warbles were extracted from an animal, the forceps were placed in disinfectant solution in a container and a fresh pair taken for the next animal. Each operator had a canvas pocket pinned over his chest, and instruments and a wide-mouthed bottle were carried in this pocket. The bottle was fitted with a rubber valve and filled two-thirds full of denatured alcohol. As each grub was extracted, it was deposited in the bottle and the jaws of the forceps immersed in the alcohol at the same time.

Another method of extraction was by means of a vacuum. A vacuum pump, operated by a gasoline engine and connected with a vacuum tank of 60 gallons' capacity, was mounted on a 4-wheel trailer. From four to six hose lines were run from the tank and each was fitted with a specially designed nozzle for extracting and retaining the grubs. This device had the advantage of removing the pus with the grub and so lessening the tendency to abscess formation. A disadvantage is that it is only 80 per cent effective in removing grubs.

In Colorado the grub openings appeared in the skin of cattle about the middle of December and extraction began December 28; it was finished March 15. In this area there were 2,912 head of cattle in 15 range herds, and 718 head in 33 farm and dairy herds, a total of 3,630 head in 48 herds at the time of the first extraction. The number of head varied somewhat subsequently. On the first extraction, December 28 to January 30 inclusive, 106,574 grubs were removed from 3,630 head of cattle, an average of 29.4 grubs a head. The time consumed in inspection and removal was 2,776 man-hours, at a cost of 50 cents an hour or a total labor cost of $1,388. This amounted to an average cost of 38 cents per animal or a little more than 1.3 cents per grub. These are labor costs and are exclusive of overhead and travel from one ranch to another. On the second extraction, January 25 to February 15 inclusive, 14,728 grubs were removed from 3,721 head of cattle, an average of about 4 grubs a head. The time consumed in this removal was 661 man-hours, with an average cost of about 9 cents per animal or 2.25 cents per grub. On the third extraction, February 23 to March 15, inclusive, 981 grubs were removed from 3,497 head of cattle, an average of about 0.28 grub a head. The time consumed was 271 man-hours, with an average cost of about 4 cents per animal or about 13.8 cents per grub. The lowered cost per animal as infestation diminishes is coordinated with an increasing cost per grub, as the time spent in extraction falls and the time spent in inspection with negative results rises. Thus it costs 38 cents a head to relieve 3,630 head of cattle of approximately 30 grubs a head, or 1.3 cents per grub, while it costs about 4 cents a head to inspect 3,497 head of cattle and find 981 grubs, or a cost of 14.8 cents per grub.

The data for the Illinois area have not yet been summarized.

Records have been kept on the probable relation of breed, age, sex, and color of animals to extent of infestation. At present these indicate only that light-colored animals are more grossly infested than dark-colored animals, and that age is apparently not so important a factor as generally believed.

PARASITES OF HORSES

NEMATODES

Studies on the control of horse parasites at the Mereworth stud near Lexington, Ky., have been continued in

cooperation with the owner and his representatives. A combination of treatments for the removal of parasites with sanitation on pastures and in barns has resulted in a marked decrease in infestation as compared with that noted in previous years. Foals and weanlings are in better condition and weigh considerably more than foals and weanlings of corresponding ages on near-by farms where control measures for parasites are not being used.

The occurrence of Strongyloides in horses in Kentucky has been noted for the first time. There appear to be no published records of the presence of this parasite in American horses. The occurrence of these worms appears to be associated with a diarrhea in foals. This subject requires further investigation.

Investigations in rendering horse manure free from living eggs and larvæ of parasites yielded successful results. A double-walled, wooden box constructed of tongue-and-groove lumber, insulated with fine sawdust and having a top made of two layers of 1-inch tongue-and-groove lumber, was used in the experimental work. Manure kept in the box for one week underwent sufficient heating to destroy the vitality of parasite eggs and larvae present.

Experiments on the resistance of the larvæ of horse strongyles to environmental factors have been in progress in Montana for nearly a year. Two lots of horse manure containing strongyle larvæ were exposed to the weather for 9 and 11 months, respectively. During this period temperatures considerably below 0° F. were recorded. Live larvæ were still present in the manure after these periods of exposure, indicating the marked resistance of the infective strongyle larvæ to low temperatures. Larvæ in water were highly resistant to temperatures ranging down to —36° F. for long periods.

When the larvæ of horse strongyles were air-dried and then kept in an incubator at a temperature of 24° to 26° C., about 10 per cent of the larvæ were still alive after about four months' drying.

MISCELLANEOUS PARASITES

TREMATODES

In view of a demand for information as to methods of handling fluke-infested livers in such a way that they could be utilized for fish food without spreading fluke disease to livestock along the streams on which fish hatcheries are situated, experiments were carried out to find means of destroying the fluke eggs in these livers. The experiments indicated that fluke eggs were killed by a temperature of about 116° F. in 15 minutes, or 121° F. in 5 minutes, 38° F. in 6 days, or 0° F. in 3 hours. In order to apply these findings to fluky livers, a large, calf liver showing a light fluke infestation was obtained and additional fluke eggs injected into the liver at several places. The liver was then placed in a room with a temperature varying between 5° and 10° F. After 24 hours, fluke eggs which had been taken from this liver and incubated became disintegrated, showing that they had been killed by freezing.

TREATMENTS FOR INTERNAL AND EXTERNAL PARASITISMS

ANTHELMINTICS

Work on a considerable number of chlorinated hydrocarbons was carried on with the view of developing new anthelmintics and ascertaining the correlations between their anthelmintic efficacy and their chemical composition and physical properties. The results, too technical for discussion in this report, add materially to current knowledge regarding these chemicals. Several of them had effective anthelmintic properties and produced no bad effects on the experimental animals.

Tests of mustard alone or added to the copper-sulphate solution for stomach worms of sheep indicated that the mustard had no direct anthelmintic value. However, there was some evidence that sheep found the mustard and copper-sulphate solution more palatable than the copper-sulphate alone.

To test the effect of weekly treatments with anthelmintics on sheep, 2 sheep were dosed weekly with 1 per cent copper-sulphate solution, 2 with carbon tetrachloride, 2 with tetrachlorethylene, and 2 were held as a check lot. The feces were examined weekly for parasite eggs. The results indicated that copper sulphate can be safely administered to sheep once a week for long periods and will keep nematode-worm infestation down to near the minimum. Tetrachlorethylene can be given with safety in the same way, and gives even better results, so far as can be judged with the number of animals involved. Both

sheep in the carbon-tetrachloride lot died, apparently as a result of weekly treatments with a drug which causes a certain amount of liver damage requiring about 2 weeks for repair.

Tests of Chenopodium, tetrachlorethylene, and carbon tetrachloride on rabbits with intestinal trichinosis showed no apparent effect in destroying the trichinae in the intestine. Chenopodium and tetrachlorethylene were fairly effective in removing the rabbit pinworm, *Passalurus ambiguus*.

INDEX CATALOGUE AND COLLECTIONS

The index catalogue of medical and veterinary zoology was continued, and new sections established to take care of growing needs. The new sections include a systematic arrangement of the nematodes, trematodes, and cestodes, and catalogues of anthelmintics and of insecticides used in the control of insect and arachnid parasites of animals. Accessions to the bureau collection of parasites amounted to 1,290.

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REPORT OF THE CHIEF OF THE BUREAU OF BIOLOGICAL SURVEY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF BIOLOGICAL SURVEY,
Washington, D. C., August 30, 1929.

SIR: I have the honor to transmit herewith a report on the work of the Bureau of Biological Survey for the fiscal year ended June 30, 1929.

Respectfully,

PAUL G. REDINGTON,
Chief.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

WILD-LIFE RESEARCH, CONTROL, AND CONSERVATION

The field of work of the Bureau of Biological Survey is briefly described by the term wild-life administration. This involves fundamental activities in research; direction of efforts for the control of species injurious to agricultural and other economic activities; and educational, regulatory, and administrative functions designed to protect and preserve harmless and useful species. The wild life coming within the province of the Biological Survey consists for the most part of vertebrate animals other than fishes, but biological surveys are conducted in basic field research that are broadly ecological and concern not only the mammals, birds, reptiles, and amphibians, but all other classes of native animals and plants that are indicators of the limits of the several natural life zones of the continent.

The Biological Survey was organized in 1885 to study the interrelationships of birds and agriculture, and in subsequent years the work was expanded to include investigations in the geographic distribution and the migratory and other habits of both birds and mammals. Detailed biological surveys were early undertaken, both on a state-wide scale and within definite natural regions covering parts of one or more States. It is from such biological investigations, though limited both as to specific groups and details of treatment, that the bureau was given its present designation.

The chief objects of the research work of the Biological Survey as now conducted are to ascertain the facts regarding the economic value, the distribution, habits, and abundance, and the relationships of the wild life of the country, with a view to the protection of useful species and those that are threatened with extinction under present-day intensive hunting and trapping and the steady encroachments of settlement and industry upon marshland, forest, and other areas essential to their perpetuation, and the control of injurious species. Control operations are not directed toward the extermination of any of the interesting native species of the wild life of the country but toward their local control when they become detrimental to farming, stock raising, or other economic interests, or to beneficial forms of wild life.

The importance of the work for which the Biological Survey is responsible is indicated not only by the increasing appropriations made by Congress for broadening the scope of its operations and enlarging its responsibilities, and the large amounts entrusted to it for expenditure in control work by cooperating States and organizations, but also by the varied services it renders in the dissemination of information through publications, demonstrations, and other methods to individuals, farmers' or-

ganizations, cooperating scientists, and institutions. Its research, service, and regulatory activities are concerned with the advancement of agriculture, stock raising, and forestry by the control of species that become economically injurious, by the protection and encouragement of useful species, by the propagation of suitable species in fur and game farming, and by combating maladies of wild animals and birds. The responsibilities of the bureau extend also to the maintenance of big-game and bird reservations and the administration of Federal wild-life legislation.

Although economic considerations should by no means be allowed to outweigh all others that are advanced for the welfare of wild life, they have a proper place in every measure considered for wild-life conservation, for man must in many places subdue nature and make it serve his purposes. Fields must replace large forest areas, and domestic livestock must supplant most of the wild ruminants, predatory animals, and injurious rodents. In the process whereby civilization, either intelligently or wantonly, is changing natural conditions, the wild life, wisely preserved and controlled, can be made an asset of great value, not only of economic but of esthetic and scientific importance, and the natural habits of many species may themselves be utilized in numerous ways, an example being furnished in the destruction of insects by birds.

The first requisite in wild-life administration is an adequate knowledge of the facts. Intricate problems are arising in the consideration of such matters as the provision of natural food supplies, the reservation of breeding areas, and the protection of wild species against their enemies. The people generally must be made more fully acquainted with the importance of these matters, as otherwise there can be no sound public policies affecting them. The history of game protection in this country was largely the story of uncoordinated action on the part of each of the several States until 1900, when Congress passed the Lacey Act. This act, extending the functions of the Department of Agriculture to include game protection, regulated interstate traffic in game birds and animals and pelts of fur bearers and importations of foreign species. It was followed in 1913 by the Federal migratory bird law, and in 1916 by the negotiation of the migratory bird treaty, under which the protection of the birds that pass between this country and Canada was made a Federal responsibility.

Wild-life administration requires competent leadership to accomplish results that will be satisfactory to economic interests, to conservationists and those interested in the esthetic phases of wild life, and to trappers and sportsmen. So far as the facilities provided for its work will allow, and with the cooperation of State conservation commissions, wild-life conservation associations, and individuals, the Bureau of Biological Survey is striving to meet its responsibilities in this great field. Competent administration of wild-life resources requires also technical knowledge well applied. It is dependent upon enlightened legislation, and this can be brought about only when the public is well informed regarding the needs and economic relations of wild life. Furthermore, it requires throughout the States a nonpolitical field force of high morale and esprit de corps, inspired by the magnitude of the achievement that is possible.

State and Federal agencies concerned with wild-life administration have both their own and interlocking fields. The Federal Government is charged with the duty of controlling injurious species of wild life on the public domain and, in cooperation with the States, is responsible for leadership in control operations elsewhere. It is responsible also for the conservation of the migratory birds of the country, both by the enforcement of restrictive legislation enacted for the purpose and by the creation and administration of refuges set aside as resting, feeding, and nesting grounds. In its research on wild life, its control operations, and its conservation activities, the Federal Government, through the Bureau of Biological Survey, supplements the efforts of each of the States to protect the species that live there and are enjoyed by its citizens. This work of the Federal Government can be successful only through the whole-hearted cooperation of the States and the people generally, and it may here be recorded that such cooperation is being extended in increasing measure. The preservation of useful and harmless species is a vast undertaking, and satisfactory solution of the intricate problems involved in wild-life welfare will redound to the credit of all who have any part in the cooperation. The ultimate objective of wild-life conservation organizations will be achieved only through a continuation of the harmonious effort that was so

greatly in evidence during the year and resulted in the enactment of the measure known as the migratory bird conservation act.

IMPORTANT ACCOMPLISHMENTS OF THE YEAR

Among the accomplishments of the year that are of outstanding importance in wild-life research, control, and conservation, or in progressive legislation for promoting conservation programs, may be mentioned the following, the details of which appear in later pages of this report:

Enactment by Congress on February 18, 1929, of the migratory bird conservation act, which has been termed one of the most important measures for the protection of wild life that have been written on the statute books of any nation. First steps were taken during the year looking to the acquisition of lands authorized thereunder for refuges for migratory birds, the need for which was stressed in last year's report.

Completion of engineering studies for improving the extensive marshes at the mouth of Bear River, Utah, as a refuge for migratory birds and as a means of checking the serious losses hitherto occasioned by alkali poisoning, and solicitation of bids for beginning the construction of the necessary dikes and river-control works.

Submission to Congress in accordance with a proviso in the appropriation act for 1929, of a proposed 10-year program of predatory-animal and rodent control on national forests and other public domain and elsewhere, in cooperation with State organizations.

A decided advance in knowledge of the diseases of elk in the southern Yellowstone region, which have caused serious losses hitherto attributed mainly to starvation in winter.

Completion in cooperation with a committee of eastern sportsmen of a 5-year investigation of quail production in southern Georgia and northern Florida, as a result of which important recommendations have been made for increasing the abundance of quail, including such measures as control of natural enemies and improvement of habitat and methods of propagation.

Determination of the breeding period of the marten, after a series of investigations conducted at the fur-animal experiment station in the Adirondack region, New York.

Determination of the fact that the so-called "distemper" of foxes in captivity covers at least four diseases, methods for combating which were improved during the year.

Increased cooperation with the States in predatory-animal and rodent control as evidenced by the promise of cooperative funds totaling $1,800,000 for the current year, as compared with $1,120,000 expended during the year just closed, and the addition of five States to the list of those cooperating.

Beginning of predatory-animal control operations in Alaska in cooperation with the Territorial Government, based on studies made during the previous year, and first effective work to check the spread of coyotes in the Territory, which will aid in protecting the birds, big-game animals and fur bearers, and the herds of reindeer.

Stimulus to control operations against jack rabbits in Western States by aiding farmers in finding a market for the pelts, which, in addition to ridding crop and range areas of millions of the destructive rodents, netted farmers and stockmen approximately $2,000,000 from the sales of pelts.

ORGANIZATION

A detailed outline of the organization of the bureau and of the functions and purposes of its field offices was presented in Miscellaneous Publication No. 49, Directory of Field Activities of the Bureau of Biological Survey, issued just before the close of the fiscal year.

Shortly after the passage of the migratory bird conservation act the Secretary authorized the creation in the Biological Survey of a Division of Land Acquisition, and preliminary steps were at once taken to organize the unit so that it might be ready to function under the new law at the beginning of the fiscal year 1930. This division has immediate supervision of all activities in the matter of examining, classifying, appraising, surveying, and acquiring wild-life refuge lands by purchase, lease, or gift, and by Executive order, not only under the new act but under other similar laws. Work of this nature under the Upper Mississippi River Wild Life and Fish Refuge act and the Bear River Migratory Bird Refuge act was taken over by the new division when it was created. It will also be a function of this division to conduct surveys incident to the establishment or enlargement, and the definition of boundaries, of all refuges maintained by the Biological Survey. Rudolph Dieffenbach has been placed in charge of the new division, the personnel of which has had long and varied training and experience in all

phases of land-acquisition work, including boundary surveys, soil classification, and land valuation.

A specific appropriation for carrying on the work of the unit concerned with fur farming and a description of its functions are contained in the agricultural appropriation act for the current year. This action was taken by Congress following requests of national associations of the fur industry, representative fur farmers, rabbit breeders, and fur tradesmen, and on recommendation of the department. The production of fur animals was first made a project of the Biological Survey in 1913, and the establishment of a separate Division of Fur Resources was authorized by the Secretary in 1924.

In order to describe more adequately the work of the division charged with control-methods research and cooperative control campaigns, its designation has been changed, effective July 1, 1929, from Division of Economic Investigations to Division of Predatory-Animal and Rodent Control; and the three major projects under the division will be designated control-methods research (with a laboratory at Denver, Colo., known as the control-methods research laboratory), control of injurious rodents, and control of predatory animals.

It is appropriate to record at this point the publication in January of a monograph by the Institute for Government Research, of the Brookings Institution, entitled "The Bureau of Biological Survey: Its History, Activities, and Organization." The author, Jenks Cameron, presented very fully without criticism or recommendations the history of the bureau, its functions, by detailing specific activities, its organization, the nature of its plant, a compilation of laws and regulations governing its operations, its appropriations and expenditures from year to year, and a full bibliography of all sources of information bearing on the bureau and its operations, including a reprinting of a 29-page mimeographed leaflet (Bi–982) issued by the bureau during the year listing all of its publications issued from the time of its establishment.

BIOLOGICAL INVESTIGATIONS OF WILD LIFE

Investigations of the geographic distribution, migration, classification, and natural history of wild animals, of animal ecology, and of the natural life zones provide many of the fundamental scientific facts essential to the administration of the wild-life resources of the country. Field studies were made of the life histories, abundance, natural requirements, and diseases and parasites of big game and other mammals and birds, the purpose being to provide a basis for improving their welfare, controlling excessive numbers, or transplanting suitable species for restocking depleted areas.

Special attention was given to problems concerning North American waterfowl, the elk herds of Wyoming, and the deer on the Kaibab Plateau, Ariz., and in Pennsylvania and Virginia, and observations also were made regarding moose, mountain sheep, antelope, caribou, and reindeer. Specimens of the bird and mammal life assembled in the extensive collections of the bureau afforded the basis for revisions of genera, for reports on special regions, and for the identification of forms involved in administrative, regulatory, and control work. Much of the work was conducted in cooperation with scientific and educational institutions.

RESEARCH ON BIRDS

In ornithological research, taxonomic, distribution, and migration studies were made and many specimens were recorded and added to the collection. The number of bird specimens now in the collection is approximately 65,000. During the year 400 birds were identified for correspondents and museums, and assistance was given the American Ornithologists' Union in the revision of its check list of North American birds.

Through the financial aid of a cooperator interested in the birds of Florida, a careful survey was made of the breeding birds of the northern and central parts of the State, and information of much value was thus obtained for use in a report on the birds of Florida, which is now ready for publication. Reports on the results of ornithological research published during the year included a circular (No. 40) on the spread of the European starling in North America; a treatise prepared in the bureau and published by the Biological Society of Washington on birds of the Washington, D. C., region; and an extensive work on the birds of New Mexico, published under the auspices of the New Mexico Department of Game and Fish. Publication of this important volume was made possible by the generosity of interested residents of the State, who underwrote the cost of printing and colored illustrations.

CENSUSES OF MIGRATORY WILD FOWL

Investigational work has been continued by means of waterfowl censuses to provide information regarding the numbers, distribution, and migratory movements of the ducks, geese, swans, and coots of North America, as a basis for administrative action regarding open and close seasons, bag limits, and other regulatory matters with which the Biological Survey is concerned under the provisions of the migratory bird treaty act. This has included field work by members of the staff and the collation of monthly reports on observations made by about 4,000 volunteer cooperators on areas selected as typical of waterfowl conditions in the United States, Canada, and Newfoundland. The waterfowl census work has continued to grow as additional observers have been enlisted, and Federal and State officials in the United States, and Dominion and Provincial officials in Canada and Newfoundland, have participated actively in organizing and conducting the work. Approximately 20,000 monthly reports on waterfowl conditions were received during the year, and comparison of the results with those of previous years shows their increasing value in affording information regarding the distribution, the seasonal and regional movements, and the increases or decreases of waterfowl.

BIRD-BANDING STUDIES

Bird banding, which has been further developed during the year as a means of obtaining information regarding the migratory movements and abundance of waterfowl, is of particular importance in working out the routes, the resting and feeding areas, and the points at which the various birds breed and winter. In cooperation with the American Wild Fowlers and the National Association of Audubon Societies studies were begun on bird refuges in Louisiana to determine methods of banding blue geese and canvasback ducks on a large scale. The ultimate results should be important in filling the gaps in our knowledge of these species.

The total number of ducks and geese banded up to the close of the fiscal year was 41,989, of which more than half, or 21,557, were mallards. Other species that have been banded in fairly large numbers were black ducks, 6,973; pintails, 6,218; blue-winged teals, 1,565; and green-winged teals, redheads, ringnecks, and lesser scaups with close to 1,000 records each. Localities where 100 or more migratory waterfowl have been banded now number 56, and are fairly well distributed from Alaska and southern Canada to southern California and the Gulf coast. Realizing the importance of these studies, many sportsmen have reported on banded wild ducks that were killed.

In addition to 29 active waterfowl-banding stations, more than 1,500 trapping stations were maintained by licensed cooperators for banding miscellaneous species of migratory birds. This work serves as a valuable supplement to the results obtained with waterfowl, as it affords information that is needed on practically all groups of North American birds in studying the general principles governing their migratory movements. Bands purchased and issued during the year totaled 249,000, and birds reported as banded in this period numbered 133,884, including 11,132 waterfowl, bringing the total number banded since 1920, the year the work was first organized, to well over half a million.

Manuscript for a manual for bird banders was in press at the close of the year, detailing with abundant illustrations efficient banding methods, and its publication will be of great help to cooperators in the project. Indicative of the widespread interest in this method of bird study are the publication by the American Ornithologists' Union of a bibliography of bird banding in America, in which are listed more than 500 titles of papers published on the subject, and the publication in the Proceedings of the Sixth International Ornithological Congress held at Copenhagen, Denmark, of a paper on bird banding in America, both of which were prepared in the bureau.

RESEARCH ON MAMMALS

In mammal research, work was continued on a general report on the mammals of Wisconsin, on taxonomic revisions of the ground squirrels of North America and on a report on the mountain lions of both North America and South America, and on the collating of the results of field surveys conducted some years ago on the mammals of Lower California. A catalogue of type specimens of mammals in the United States National Museum, including the Biological Survey collection, is being prepared. Assistance has also been given to vis-

iting scientists who were working on special problems involving the use of the bureau's records or collections. Indicative of the demand for assistance is the fact that information has been supplied on request to the following Government offices in Washington, in addition to other bureaus of the department: The Public Health Service, the public schools of the District of Columbia, the Metropolitan police of the District of Columbia, the Office of Public Buildings and Public Parks of the National Capital, the National Park Service, the National Museum, and the National Zoological Park. Mammal specimens to the number of 831 were identified for 37 institutions or individuals, representing 22 States and 2 foreign countries, and a considerable interchange of specimens was made between the Biological Survey and other research institutions for use in special studies. The mammal specimens in the Biological Survey collection now number approximately 131,000.

One number of the North American Fauna (No. 52), Revision of the American Chipmunks, Genera Tamias and Eutamias, and a technical bulletin (No. 145) on Life History and Habits of Grasshopper Mice, Genus Onychomys, were in press at the close of the year. Manuscripts of reports on the mammals of New Mexico, the mammals of Oregon, the mammals of Yellowstone National Park, pocket mice of the Northwest, and the pocket gophers of the United States were completed for publication, and a circular, Studies of Mammalian Life Histories, was revised for reissue. Work was continued also on an account of the life history and taxonomic status of the caribou, including careful comparison with Biological Survey collections of all specimens in the National Museum in Washington, the American Museum of Natural History in New York City, the Academy of Natural Sciences of Philadelphia, and the Field Museum in Chicago.

INVESTIGATIONS OF DEER

At the request of the State game commission, the bureau has continued to cooperate in studies of factors affecting the deer in Pennsylvania. This has included field investigations and the submission of detailed reports on conditions as found. The game commission has published these reports to use as a basis for educational work and administrative action in the management of the deer, including the fixing of open seasons. At a conference called by the game commission at Harrisburg, Pa., a member of the bureau was designated to serve as leader of a committee then selected to make a thorough fact-finding investigation regarding conditions affecting the deer, including the various causes of mortality, possible malnutrition or starvation, weakening by parasites or diseases, and of the nutritive value or possible toxic properties of plants eaten by deer. The committee includes representatives of the State Bureau of Animal Industry, the State Agricultural College and Experiment Station, and Bucknell University.

At the request of the commissioner of game and inland fisheries of Virginia, representatives of the bureau made a preliminary survey of the abundance of deer in three counties in the western part of that State, and of the various factors affecting them, including available food and depredations by predatory animals, particularly bobcats. The report, with recommendations for bettering conditions, was published by the commission, which is taking steps to put into effect the management practices recommended.

Two representatives of the bureau took part also in a study made during the spring of conditions affecting deer on the Kaibab Plateau, north of the Grand Canyon, Ariz., in cooperation with representatives of the Forest Service of this department, the National Park Service of the Department of the Interior, and the State game department of Arizona. Observations were made on the numbers of the deer, their condition at the close of the winter, the extent and causes of mortality among them, and the effect of their browsing and grazing on forest trees, and forest reproduction, and the available food supply.

ELK INVESTIGATIONS IN WYOMING

Losses of elk at the refuge in Jackson Hole, Wyo., were found comparatively light during the winter, particularly among the fawns. Many of the animals wintered successfully on the natural ranges, and the feeding season was therefore short and the losses few, only 76 elk having died on the refuge, as compared with 409 during the previous winter. The major cause of the loss continued to be necrotic stomatitis. The findings thus far have made it possible to improve the management of the herds and the selection of winter food, to the betterment of the health of the animals.

Particular attention has been given to a study of the factors governing the increase or decrease of the southern Yellowstone elk herd, and the work has been coordinated with investigations of the northern herd through cooperation with the National Park Service. In addition to the intensive work upon diseases, arrangements have been made to ascertain the annual kill by hunters and the extent to which predatory animals may be responsible for losses, particularly among the fawns.

Careful observation is being made of the herds while feeding, and the findings are proving of much interest and importance. Following this, intensive studies are made of the plants present on the feeding area and the extent to which the animals have grazed upon them. These studies deal with the palatability of the various plants, the discrimination displayed by the animals in feeding upon certain kinds and leaving closely related species untouched, and, through cooperation with the agricultural experiment station of the University of Wyoming, with chemical analyses of plants, including representative species of both winter and summer forage. Material from elk licks also is being analyzed in order to learn definitely what mineral constituents attract the animals.

Important information is being obtained regarding the general condition of the elk, their numbers, their various habits or traits, and such physical features as size, weight, and rate of growth. This work is being conducted along ecological lines, to bring into the record essential information regarding the interrelationships of all members of the flora and fauna of the region, including the activities of various rodents and predacious animals and birds. Motion pictures were made to illustrate important features in the life history and behavior of the elk. Attention also has been given to other big-game animals of the locality, including mule deer, moose, and mountain sheep.

WILD-LIFE RESEARCH IN NATIONAL FORESTS AND PARKS

Arrangements were nearly completed for undertaking a program of research in the relationships that birds, mammals, and other vertebrate animals sustain to forestry development, a study made possible by the provisions of the McSweeney-McNary Forestry Research Act. A representative of the Biological Survey attended the annual meeting of the Appalachian Forest Research Council at Asheville, N. C., and outlined a program of experiments and investigations of the life histories and habits of the various forest-inhabiting species, to ascertain their beneficial and injurious relationship to forest resources and their value as forest products. Preliminary field investigations were made at a number of points in this experiment-station district, and other measures were taken for launching the work effectively during the coming fiscal year. An article showing that wild animals affect forest production in many ways was published in the Yearbook of Agriculture, 1928.

Studies were continued in the Grand Canyon National Park and surrounding territory in cooperation with the Carnegie Institution of Washington, the National Academy of Sciences, the National Research Council, the National Park Service, and the Forest Service. A field naturalist was engaged upon this work during May and June to make extensive collections of specimens, study the life history and habits of animals, and determine the life zones of that region, including San Francisco Mountain. The results will be of great value in the comprehensive educational program that is being carried forward by the cooperating agencies to assist the visiting public in appreciating and profiting from the remarkable natural phenomena of this region.

REINDEER INVESTIGATIONS IN ALASKA

Studies in progress for the improvement of the Alaska reindeer are concerned primarily with herd management, breeding experiments, including crossbreeding of reindeer and caribou, disease and parasite control, forage resources and grazing practices, range recovery from overgrazing and fires, and the utility of various cultivated feeds grown locally. In these studies close contact is maintained with firms and individuals engaged in producing reindeer in the Territory and with officials of the Bureau of Education of the Department of the Interior, which is concerned with the production and use of reindeer by the native population. A statement was issued in February by a joint committee of the Departments of Agriculture and the Interior on the status of reindeer meat, showing that it is not included under the Federal meat-inspection act, but that when shipped interstate and marked for identification, it may be handled in federally inspected plants.

Injury to reindeer and reindeer products by warble flies, nose flies, and

other insects, occasioning an aggregate loss to producers of many thousands of dollars annually, caused the Alaska Legislature at its recent session to appropriate $10,000 to assist the bureau in determining means of relief. A mimeographed leaflet (Bi–1012) on reducing the number of warble and nose grubs in reindeer was issued in March. A cooperative agreement was completed between the Bureau of Biological Survey, the Bureau of Entomology, and the Territory of Alaska, through the governor, for procedure to be followed in the investigations. In June an expert entomologist was detailed by the Bureau of Entomology to undertake a thorough study of the life history and habits of these parasitic insects and their relationship to reindeer, and to develop methods of control.

The Biological Survey maintains a reindeer experiment station of about 1,200 acres near Fairbanks and a substation for the western coastal area at Nome. Under its jurisdiction also is Nunivak Island, which was set aside by Executive order of April 15, 1929, for use in conducting experiments in the crossbreeding and propagation of reindeer and native caribou and for contemplated experiments in reestablishing musk oxen in Alaska. The crossbreeding experiments with caribou and reindeer were begun on Nunivak in 1925, and this reservation will insure protection of the experiment and facilitate its orderly progress. The capture of caribou during the year by roping from canoe and power boat during their migration across Harding Lake, near Fairbanks, has afforded a means of obtaining animals for experimental work.

Progress was made in reindeer-feeding experiments, and a cooperative agreement was entered into with the Bureau of Animal Industry to conduct intensive studies of the nutritional problems involved in the use of the various available types of feed by both caribou and reindeer. The Bureau of Chemistry and Soils has aided materially by making analyses of forage plants.

Meteorological instrument stations for the study of moisture and climate in relation to reindeer and plant growth were established at three points: Nome, on the Bering Sea coast; near Fairbanks, in the Tanana Valley of the interior; and in Broad Pass, on the Alaska Range. These stations, situated in typical areas, will prove exceedingly helpful in studying the varied climatic conditions affecting the animals and the forage growth throughout Alaska.

The facts deduced in the reindeer investigations, and the conclusions thus far reached, are providing a sound foundation for improvement in the reindeer industry. Reindeer production furnishes a means for the efficient utilization of the vast forage yield of Alaska; it is important to the social and economic development of the native people, and with further development may provide a market for grain and hay raised by local farmers. A circular (No. 82), Improved Reindeer Handling, was in press at the close of the year.

RESEARCH ON FOOD HABITS OF WILD LIFE

LABORATORY INVESTIGATIONS AND STOMACH ANALYSES

FOOD OF BIRDS

The main investigations during the year on the food of birds did not take the usual form of research on specific problems but consisted mainly of special examinations of groups of birds from different parts of the country on the request of various individuals and institutions interested. One lot of stomachs examined consisted of those of more than 50 ruffed grouse and a few ring-necked pheasants, information on the food of which was desired by a committee making an investigation of ruffed grouse in New England, with which the bureau is cooperating. Other special examinations concerned the feeding habits of fish-eating birds, jays, and woodpeckers, from California; butcher birds, collected to round out data in connection with the cooperative quail investigation in Georgia; birds from Florida supposed to be feeding upon the celery-leaf tyer; jacksnipe, from Wisconsin, to determine the extent of their vegetable food; and a variety of insectivorous birds, collected in Montana, to learn their relation to the mountain pine beetle.

A few miscellaneous stomach examinations of migratory birds were made to learn whether the protected status of these birds under the migratory bird treaty act should be changed. The care of reference collections of insects, seeds, skeletons, and other material used in identifying the stomach contents of birds and other species being studied was made a special feature of this part of the work. The seed collection now contains representatives of more than 3,000 species.

There was published during the year a farmers' bulletin (No. 1571) on the European starling, with suggestions for control measures when necessary. A comprehensive report was completed for publication on the English sparrow in the United States, intended to reflect the present economic status of the bird, as well as a leaflet on recommended measures of control.

USEFULNESS OF HAWKS AND OWLS

In the spring of 1927 the game commission of Yakima County, Wash., established a bounty on various predatory species supposed to be destructive to useful birds, especially to upland game birds. Arrangements were made for the preservation of the stomachs of hawks and owls killed and presented for bounty, and 121 of these, 5 kinds of hawks and 2 of owls, were forwarded to the Biological Survey for study. Of 45 stomachs of Swainson's hawks, 40 containing food held about 90 per cent ground squirrels, the remainder consisting of snakes and grasshoppers and other insects. Of 31 of red-tailed hawks, 27 held food, of which 83 per cent was ground squirrels, 6 per cent rabbits, 4 per cent meadow mice, and the remainder snakes. These hawks and owls, for the killing of which a bounty was paid, had been preying chiefly upon ground squirrels, rabbits, and mice, species so destructive in the Western States that the Federal Government and the States have been cooperating for years in campaigns to control them. No game birds whatever had been eaten by any of the 121 hawks and owls killed, and only 3 birds of any kind. It is gratifying to be able to record that as a result of the findings of the Biological Survey bounties on hawks and owls are no longer paid in Yakima County.

FOOD OF OTHER VERTEBRATES

The principal item of laboratory work upon vertebrates other than birds was examination of the following mammal stomachs: 25 of harbor seals from Washington State, to learn their relation to the fishing industry; 33 of prairie dogs from Arizona, collected to show the relation of these animals to forage for livestock; and a lot of more than 80 miscellaneous species from North Carolina, information on which was desired to show the relation of the animals to reforestation. In addition a few examinations were made of stomachs of reptiles. At the close of the year a technical bulletin (No. 147) on the habits and economic status of the alligator was in press.

FIELD INVESTIGATIONS OF SPECIES REPORTED INJURIOUS

BIRDS AND MAMMALS IN RELATION TO FRUIT AND BULB PRODUCTION

There has recently arisen considerable agitation in California for the suppression of bud-eating and fruit-eating birds. Two representatives of the bureau were detailed to investigate the situation, and it is hoped thereby to obtain results that will be satisfactory both to the fruit growers and the bird lovers. Some years ago a similar request was investigated and the results published in bulletins of the Biological Survey.

Further investigations of field problems in the food habits of wild animals concern the relation of moles and rodents to the expanding bulb-growing industry in the Pacific Northwest. This work has been carried on for three years and sufficient information is now at hand for the preparation of a report. Investigations also were made of the relation of bats to the codling moth in the Northwestern States.

FOOD HABITS OF RODENTS

Progress was made on studies of test areas in Arizona to ascertain the destructiveness of various rodents to forage and to compare the condition of plots to which rodents only, cattle only, both rodents and cattle, and no grazing animals had had access. This work is just now entering a new phase in which the rate, quantity, and quality of recovery of the vegetation following operations for the control of prairie dogs will be studied. Not only is destruction of forage involved, but since denuded lands are more subject to erosion, the effect of rodents in increasing erosion is being measured. A manuscript on the habits and economic relations of the southwestern porcupine was nearly completed during the year, and a farmers' bulletin (No. 1598), Mountain Beavers in the Pacific Northwest, was in press at the close of the year. Studies were continued of the food habits of pocket gophers and a report completed for publication.

STUDIES OF BIRD-ATTRACTION METHODS

The experiments in attracting birds to the experimental chestnut orchard at Bell, Md., being carried on in co-

operation with the Bureau of Plant Industry, continue to yield good results from year to year. In 47 bird boxes erected on a tract of 2½ acres there were produced during the season of 1926, 17 partial or complete broods of birds, an average of 6.8 broods to the acre. In 1927, with the same equipment, the number of broods rose to 40, an average of 16 to the acre. In 1928, 52 additional bird houses were erected, making a total of 99, scattered over 3½ acres, and 65 broods were produced, an average of 18.5 to the acre. The kinds of birds and the number of broods of each in 1928 were as follows: House wren, 33; European starling, 9; English sparrow, 8; purple martin, 7; bluebird, 6; flicker, 1; and crested flycatcher, 1. This cooperation with the Bureau of Plant Industry is enabling the bureau to experiment in bird-attraction methods and is yielding valuable information in that field, as well as fulfilling the primary object of the studies—from the point of view of orchard management—namely, to increase the number of insectivorous birds in the locality.

In the line of bird-attraction methods, there was published during the year a leaflet (No. 36), Gourds for Bird Houses and Other Purposes, and an article for the Yearbook of Agriculture, 1928, entitled "Birds Can Be Attracted to Wood Lots by Various Measures and Practices."

DUCK MALADY IN THE WEST

Near the close of the fiscal year preliminary work was done in an investigation in Oregon of a destructive duck sickness that differs somewhat from that previously identified as alkali poisoning in the Bear River marshes of Utah. A field laboratory was established and necessary experimental pens constructed at Klamath Falls, Oreg., a promising center for the investigation. It is hoped with this early start, and with cooperation promised by specialists, to make even greater progress in the study of this malady during the present season than has heretofore been achieved.

FOOD RESOURCES OF MIGRATORY BIRDS

Studies were made of various areas from the standpoint of their food resources for wild fowl. One of these was at the mouth of the Chesapeake and Delaware Canal, in Maryland, where it was suspected that salt was damaging the duck-food plants. This suspicion proved to be unfounded. A study was made also of conditions on the St. Clair Flats, in Michigan, where it was apparent that the low-water level that had prevailed in the Great Lakes for several years was a factor unfavorably affecting the duck-food plants. At the time of the investigation and subsequently the water level had appreciably risen, and the condition of aquatic plants is greatly improved.

FOOD SURVEYS OF REFUGE AREAS

During the latter part of the fiscal year data were being gathered preparatory to undertaking studies of the wild-fowl food resources of areas for Federal migratory-bird refuges, and in the last month three parties were in the field actually engaged in the work.

The third season of intensive investigations of food plants on the Upper Mississippi River Wild Life and Fish Refuge was utilized to conclude a study undertaken principally to reveal the resources of the region as a feeding place for migratory wild fowl as well as the possibilities of improvement. Detailed reports have been made on local areas, and in this final year a general report summarizing the findings for the whole area was prepared. This included a full description of the aquatic and marsh flora, with special reference to factors controlling distribution, abundance, and development of food plants for wild fowl. In addition, information incidentally gathered was included regarding the birds, fur bearers, reptiles, amphibians, fishes, crawfishes, and mussels.

Studies were made at Detroit, Mich., also in connection with the proposed establishment of a refuge there for water birds. A report that was prepared on the aquatic and marsh flora of the Huron Mountain region of the Upper Peninsula of Michigan, with suggestions for improvements for the benefit of the wild fowl, was published during the year by the Huron Mountain Club.

INVESTIGATIONS IN THE PROPAGATION OF GAME BIRDS

COOPERATIVE QUAIL INVESTIGATION

During the concluding year of the cooperative quail investigation in southern Georgia and northern Florida efforts were concentrated on completing the various lines of study, examining stomachs of quail collected, and preparing the final report. At the close of the year the manuscript of the report was practically complete, and the cooperating sportsmen plan to publish it in book form.

OTHER UPLAND GAME BIRDS

In the course of the year's work preliminary arrangements were made for a proposed cooperative study of quail, ruffed grouse, introduced partridges and pheasants, and other game in the Middle Western States. Agreements covering the details of cooperation with officials of the State Universities of Michigan, Wisconsin, and Minnesota and the Sporting Arms and Ammunition Manufacturers' Institute have been signed, and it is probable that the investigation, the different projects of which are to be supervised and coordinated by a representative of the Biological Survey, will later be extended to other sections of the country.

An article was published in the Yearbook of Agriculture, 1928, entitled "Waterfowl Breeding a Necessary Adjunct to Protective Measures." The farmers' bulletin on Propagation of Game Birds has been revised and rewritten and the information will be published during the coming year in two parts: Farmers' Bulletin No. 1612 dealing with aquatic game birds, and Farmers' Bulletin No. 1613 on upland game birds.

INVESTIGATIONS IN FUR-ANIMAL PRODUCTION

FUR-FARMING INVESTIGATIONS

The developments in the production of fur animals on farms are due, in the main, to the increasing popularity of furs and the steadily diminishing supply of the animals in the wild. Under sound business and scientific management the profits derived from the sale of pelts are greatly stimulating the growth of fur farming, and interest in this field has been maintained also by prices paid for breeding stock. It is being demonstrated constantly that the natural supply of furs can be supplemented by raising fur animals under the care and protection of man. Fur farming, however, is not limited to raising the stock in inclosures, but utilizes large areas of land where the animals can roam at will. The business is steadily developing and has become a permanent form of land utilization. Lands used for fur farming are usually such as have little value for agriculture.

There are approximately 5,000 fur farms in the United States and Alaska, and between $20,000,000 and $25,000,000 is invested in the business. These figures do not include the vast areas of muskrat marshes in many parts of the country, many of which also are operated privately or by the States as fur farms. Growth in the fur industry has been accompanied by steadily increasing competition. In sections of the country where foxes and fox furs are not of the best quality, some producers have been crowded out; yet the business continues to increase. Approximately 80,000 silver-fox pelts were marketed in the United States and Canada during the past year. Fox farmers and their associations should study the significance of these facts and figures if the rapidity with which the business is developing is not to become a detriment to its progress through overproduction.

The pelts of fishers, martens, minks, otters, and raccoons generally bring high prices, and the skins are of fine and lasting quality. Their comparative scarcity has stimulated raising them in captivity. Mink, muskrat, and rabbit raising have developed more rapidly during the past year than have the other branches. The demand for young minks has exceeded the supply and the animals have commanded high prices. Muskrat-ranch owners in the East have shipped large numbers of live muskrats to the Pacific Coast States and to European countries for stocking marsh areas. That muskrat farming in marsh areas has become a profitable industry was shown in an article in the Yearbook of Agriculture, 1928.

Rabbit raising is now assuming large proportions as a minor agricultural business in various sections of the United States, especially in California and the Middle West. Large quantities of domestic rabbit meat have been sold in Los Angeles, San Francisco, Portland, and Seattle, though it has not yet been established as a staple in the majority of our large cities. The general public does not realize the value of rabbit meat in the diet even though it is relatively cheap, is of excellent quality, and can be prepared for the table in many ways. In cooperation with the Bureau of Home Economics, a mimeographed leaflet (Bi–1026) on cooking domestic rabbit was issued preliminary to the preparation of a formal publication on the subject.

Advertisements of large corporations selling fur animals have had both a good and a bad effect on the industry. That dishonest fur farmers and companies should use fur animals as a means of obtaining money from persons unfamiliar with the business is only to be expected, though deplored. Chambers of commerce, better-business

bureaus, the Federal Postal Service, fur-farmers' organizations, and fur-farming and fur-trade periodicals, however, have solicited the bureau's cooperation in bringing to the attention of the public the necessity of thorough study before investing, and the bureau issued a leaflet (No. 27), Recommendations to Beginners in Fur Farming, during the year.

Large numbers of fur animals are still taken in the wild, and the raw-fur harvest is worth to the trapper approximately $65,000,000 each year. The fact also that $31,000,000 worth of raw furs are exported annually is intensely significant to the farmer. Statistics on the fur trade show that the United States is now the greatest commercial fur-producing and fur-consuming country in the world. This was recognized by the Secretary in recommending that the invitation extended to this Government by that of Germany be accepted to participate in the International Fur Trade Exhibition and Congress, to be held at Leipzig, Germany, in 1930. Further development of the export trade can no doubt be fostered by participation with an attractive exhibit.

Prospective fur farmers and those already engaged in the business recognize that the bureau has available a fund of valuable information in this comparatively new field of agricultural production. Also, the Biological Survey is frequently called upon by representatives of foreign countries and by foreign fur farmers for information and guidance in planning and establishing fur farms and fur-animal experiment stations. Government representatives from England, Germany, France, Russia, Norway, Sweden, Czechoslovakia, Switzerland, and Estonia have visited the United States to study methods of breeding, feeding, and managing fur animals in captivity, and of treating fur-animal diseases and parasites, and on several occasions representatives of the bureau have accompanied them to its fur-animal experiment station or to private fur farms. Permission also has been granted upon request to translate department publications on fur animals into several foreign languages.

Demands are being made constantly that the bureau extend its operations to expedite its investigations. The desired results, however, can be accomplished only with adequate facilities for expansion, and these are lacking at present. Were they fully available, the bureau could better serve all who are interested in developing the fur resources of this country.

FUR-ANIMAL EXPERIMENT STATION

The research work conducted at the fur-animal experiment station maintained at Saratoga Springs, N. Y., has attracted the attention of fur farmers generally and of scientists in practically all countries interested in fur farming. Particular interest is being shown in the investigational work relative to the feeding and handling of fur animals. Of special appeal to fur farmers are the various methods of holding the animals in captivity, different types of dens and nest boxes devised to give satisfactory service, the effect of various rations on health of stock and quality of fur produced, and the cost of feeding. The bureau's investigations have made available accurate and comprehensive figures on the cost of feeding fur animals. During the year a mimeographed leaflet (Bi–990), A Comparison of Feed Costs with Pelt Values of Silver Foxes, was prepared to meet the demand for this information.

Fur-animal production does not yet have the background of scientific research that is enjoyed by the domestic livestock industries. Many fundamental matters, such as the breeding and gestation periods of the various species of fur animals, are still problematical. A definite accomplishment, however, has been recorded in the case of the marten. It has been generally believed that only during January and February could male martens be permitted to live with the females. Observations at the fur-animal experiment station have now demonstrated, however, that the normal mating season in the marten occurs during the summer months, usually between the middle of July and the third week in August, and not in winter, as had been supposed. The period between mating and birth therefore ranges from approximately 8½ to 9 months (259 to 275 days) instead of 60 to 102 days as has been heretofore believed. It has required many years' work for the bureau to establish the facts relative to marten breeding, because of an insufficient number of breeding animals. Observations are being continued along the same lines with martens and with badgers; and fishers and other fur bearers will be included when a sufficient stock is available for the purpose..

Practical tests in breeding and feeding have been conducted with red,

cross, and silver foxes, martens, and badgers. Badgers, the latest addition to the species kept at the station, were obtained by field men of the bureau in the course of work in predatory-animal control. Although badgers have been held only a short time at the station, investigations elsewhere have shown that they are adapting themselves to captivity and are producing young. The rabbit investigations at Saratoga Springs were discontinued and the stock shipped to California after the establishment of the rabbit experiment station at Fontana.

RABBIT EXPERIMENT STATION

The rabbit experiment station, established through the cooperation of rabbit breeders in the vicinity of Fontana, Calif., the local branch of the National Rabbit Federation, and the Bureau of Biological Survey, gives promise of exerting great influence on developments in rabbit raising. The year's work has been most successful, with the continued splendid cooperation manifested by the sponsors of the station and by rabbit breeders generally. The additional hutches and pens constructed during the year provide equipment to accommodate 600 experimental animals. Rabbit breeders in California, as well as in other sections of the United States, realize the value of this work and the relation it bears to the industry. A mimeographed leaflet (Bi–983) descriptive of the work and organization of the station was issued during the year.

Plans for five major feeding experiments with 125 rabbits were put into operation last August. At the end of the year there were 191 mature utility rabbits, 113 young available for additional experiments, and 26 rabbits representing fancy breeds. From 88 breeding does in two experiments, 1,182 young were produced, of which 752 were carried through the weaning period.

The experiments were somewhat handicapped by losses from an unknown malady, which reached epizootic proportions in many sections of California. Losses among domestic rabbits in the Pacific Coast States and in others were first noted in January, 1929, and soon thereafter were reported to the Rabbit Experiment Station as increasing rapidly. The station was besieged with appeals for help, but could do little during the year, as the personnel did not include a specialist on animal diseases, and laboratory facilities were not available. The cooperation of research workers in this field of the Universities of Minnesota and Southern California was enlisted, however, and valuable assistance has been received. It is planned to expand this line of research as rapidly as facilities are provided. Without adequate and authentic information on rabbit diseases, the industry is at a disadvantage, and large investments are being jeopardized.

Breeding and feeding experiments have been planned to determine the best and cheapest methods by which rabbits can be raised to marketable age, with profit from both meat and fur. In addition an experiment is in operation to ascertain the fertilizer value of rabbit manure, and a mimeographed leaflet (Bi–994) on the subject was issued during the year in cooperation with the Bureau of Chemistry and Soils.

Farm boys and girls in California have taken a keen interest in rabbits, and the director of the experiment station has assisted agricultural extension agents in organizing 4–H rabbit clubs. Invitations have been sent to the schools of California to visit the station, and boys and girls interested in 4–H club work have taken advantage of this to learn about the profits in the industry. An exhibit to demonstrate the work of the station was displayed and was well received at five fairs in California.

Three thousand persons visited the rabbit experiment station and about half as many the fur-animal experiment station during the year. Though not all were chiefly interested in raising fur animals, most of them took away much information on the subject.

FUR-ANIMAL DISEASES

Investigations in diseases of fur animals have been concerned mainly with studies of parasites and their control and epizootics on fur farms. Numerous critical tests were made to determine the value and safety of tracheal brushes in the treatment of foxes for the removal of lungworms. Results indicated that treatment in this manner once a month is fairly effective, even though the foxes are kept on more or less badly infested ground. To supply information requested by fox farmers a mimeographed leaflet (Bi–1010) on the treatment and control of lungworm trouble in foxes was issued, and at the close of the year a leaflet (No. 47) entitled

"Hygiene in Fox Farming" was in press.

Improved methods of handling diseased foxes during treatment have been devised, and studies regarding their tolerance to various drugs continued. To demonstrate safe methods of handling and treating fur animals a motion picture was made during the year at the fur-animal experiment station, entitled "How to Handle Foxes." It is designed primarily to interest veterinarians and to demonstrate the liability of serious injury in handling foxes unless the precautions recommended are taken. A short article was published in the Yearbook of Agriculture, 1928, entitled "Fur Farmers Aided by Research in Combating Outbreaks of Disease."

The cooperative research on diseases of foxes in captivity, which has been carried on jointly by the medical school of the University of Minnesota and the Bureau of Biological Survey since the fall of 1927, is most complete and comprehensive and has been made possible through coordination of field and laboratory investigations. Research workers representing the Rockefeller Foundation, the Mayo Foundation, the Pasteur Institute (Paris), and the Johns Hopkins University have become interested and are cooperating in their various fields.

The mortality rate of epizootic fox encephalitis, found to be a disease of both young and adult animals and to have fatal termination usually in a short time, has been materially reduced on certain experimental ranches by vaccination with ricinoleated virus. On other ranches where the vaccine was used as a protective measure no mortality was reported. Vaccination with three or four doses of the virus appeared to give a marked immunity from the disease.

In the present state of knowledge the term "distemper" is being commonly applied to more than one of several fox diseases. Thus far two epizootic diseases have been described for foxes, one an infection by a paratyphoid bacillus, and the other an encephalitis that apparently is not caused by a bacterium but rather by a filterable virus. During the year investigations revealed that foxes were subject also to broncho-pneumonia and tuberculosis.

In Alaska, in cooperation with the governor of the Territory, work in fur-animal diseases has been of assistance to the fur farmers. Lack of equipment, such as a fur-animal experiment station, experimental stock, and adequate laboratory facilities, handicaps the work on disease and other research in the production of fur animals in the Territory.

RESEARCH IN METHODS OF WILD-LIFE CONTROL

To bring injurious rodents, predatory animals, and other harmful species under control calls for constant research to determine the effectiveness of poisons and economical methods of using them. Research along these lines was carried on throughout the year at the bureau's control-methods research laboratory at Denver, Colo., and at various points in the field where actual control operations were being conducted.

A reorganization of the research work was put into effect during the year, whereby the laboratory was moved to larger and more suitable quarters to permit the installation of necessary equipment; the employment of a qualified chemist to work on the physical and chemical properties of various poisons in order to ascertain their fitness for use in the field; and prosecution of pharmacological studies to determine lethal dosages and the general effect of various poisons on the different animals. The territory in which field operations are conducted was divided into five districts, each under the direction of an investigator who makes careful observations on the acceptance of the different poisons by the various rodents and predatory animals and notes their toxic efficiency under natural conditions.

An improvement in control-methods research as a result of this reorganization is already evident. An illustration of the benefits derived is furnished by a rancher in Santa Clara County, Calif., who saved $4,300 by following methods recommended by the district investigator for the control of ground squirrels. This rancher had been prepared to use a fumigant in treating 4,500 acres at an estimated cost of $4,500, but as experiments showed that under prevailing conditions on the area it would have been highly expensive and unsatisfactory, a poison mixture employing specially prepared steam-rolled oats as the bait was recommended and used satisfactorily at a cost of only $200.

The laboratory also prepares special poisons in quantity for use in cooperative control campaigns throughout the United States. During the year an improvement was made by preparing predatory-animal poison in tablet form.

Although much has already been done to improve methods of control, there are several problems that require solution. For example, the fact that the Columbia ground squirrel of the Northwest and the California ground squirrel can withstand comparatively large doses of some toxic agents, and will not take certain baits, makes their control difficult and requires that more effective methods be devised. In the Southwest, also, a problem in control methods is presented because the jack rabbits there do not congregate in large numbers as they do in the Northwest. The control of pocket gophers also presents special difficulties in certain localities because of the variation in their habits.

During the year, as a result of research on control methods, a manuscript was prepared on the chemical and physical properties of thallium and its use in rodent control. A mimeographed leaflet (Bi–1028) was issued giving the results of various experiments to determine the effects on gallinaceous birds of rodent poisons. The experiments and field observations have proved that grouse, pheasants, quail, and domestic chickens possess a relative immunity from strychnine poisoning and that these birds are not likely to be harmed by eating rodent poison in which strychnine is used in the proportion recommended by the Biological Survey.

The development by the bureau of powdered red squill as a poison for rats has been of vast importance. The use of this poison, which has proved to be practically a specific for rats, has made it possible to carry on poisoning operations under circumstances that in the past would not permit the use of poison of any kind because of the danger to human life and domestic animals. A technical bulletin (No. 134), Red-Squill Powders as Raticides, was in press at the close of the year, and an article entitled "Rat Control Aided by Development of Effective New Poisons" was published in the Yearbook of Agriculture, 1928.

COOPERATION IN WILD-LIFE CONTROL

The economic importance of controlling injurious wild-mammal pests can not be overemphasized. Predatory animals, such as coyotes, wolves, mountain lions, bobcats, and some stock-killing bears, make serious inroads not only on domestic sheep, cattle, pigs, and poultry, but on the wild game animals and the ground-nesting and insectivorous birds of the country. Injurious rodents and other small mammals, such as ground squirrels, prairie dogs, jack rabbits, pocket gophers, woodchucks, porcupines, mice, native and introduced rats, and moles, cause losses in farm crops and range forage in the United States that run into the hundreds of millions of dollars annually. Since the inception of control work by the Biological Survey, cooperative campaigns have been more effectively organized and conducted each succeeding year. The success attained has been watched and approved by farmers, stock owners, and other cooperators, with the result that the bureau is continually urged to a further extension of the work. The campaigns have been followed by a marked decrease in the numbers of predatory animals and injurious rodents in the sections covered and by a corresponding increased production in farm crops and livestock.

Funds authorized in 1929 by States, counties, and other agencies for cooperation with the bureau in predatory-animal and rodent control for use during the fiscal year 1930, are indicative of the general popularity of the work. The amount thus authorized is in excess of $1,800,000, which is considerably more than for the present year and the largest amount the bureau has had since it began its cooperative control operations.

The policies and recommendations adopted at the conference of leaders in rodent and predatory-animal control, held last year at Ogden, Utah, have had a noticeable effect in bringing about better coordination and the adoption of more uniform practices, with resultant increased efficiency. Closer cooperation with the Forest Service and a better understanding between field forces have resulted from a letter addressed by the head of the Forest Service to all district foresters on the subject of cooperation with the Biological Survey in its predatory-animal and rodent control program. This letter points out that where rodents or predatory animals are found on national forests, the direction, control, and application of methods of eradication become the responsibility of the Biological Survey, and urges field men to perpetuate and improve this form of cooperation between the Biological Survey and the Forest Service.

Federal and cooperative funds available during the year permitted organized field work in the control of predatory animals and injurious rodents in 29 States. The Federal funds totaled

$559,239, of which $31,557 was used in control-methods research, $318,225 in the control of predatory animals, and $209,457 in the control of rodents and other small-animal pests. Cooperative funds from 17 of these States aggregated $357,210. In addition, cooperating counties, livestock and farmers' associations, and individuals contributed $1,036,969; bringing the total of cooperative funds to $1,394,179, of which $517,518 was used against predatory animals and $876,661 against rodents. The Federal funds and funds contributed by cooperating agencies and expended during the year under the leadership of the Biological Survey amounted to $1,953,418.

TEN-YEAR PROGRAM RECOMMENDED

The success thus far attained with the limited resources indicates the even greater accomplishments that might be expected if the bureau were equipped to carry out an adequate control program. Congress gave this matter consideration and as a proviso to the act making appropriations for the department for the fiscal year ended June 30, 1929, called for an investigation as to the feasibility of a cooperative program for the control of these wild-animal pests extending over five or more years. This investigation was made, and a report thereon recommending a 10-year program was submitted to Congress and printed as a House document (No. 496, 70th Cong., 2d sess.). Many farmers' and stockgrowers' organizations and other interested agencies have adopted resolutions urging that the program as called for in the report be put into operation.

CONTROL OF PREDATORY ANIMALS

Predatory-animal control operations were carried on during the year in all States from Montana to Texas and westward and also in South Dakota, Oklahoma, and Arkansas. Many requests were made for more extensive operations in the range States in which work is now being conducted and in other States, including Wisconsin, Michigan, Minnesota, New Hampshire, North Dakota, Virginia, West Virginia, and Missouri. Except in a temporary way and in a few instances, it has not been possible to meet these demands. One hunter was detailed from the South Dakota district to assist in the control of coyotes in Steele County, N. Dak., through an arrangement whereby the county paid the expenses. Similar arrangements are under way to assist in controlling bobcats and predatory bears in Virginia and West Virginia. Consideration is being given also to requests from Wisconsin and Minnesota, as it may be possible for State agencies to provide the necessary cooperative funds.

Cooperative arrangements for predatory-animal control in Alaska were continued during the year between the bureau and the Territorial government. Investigations disclosed serious destruction of deer, mountain sheep, and other big-game animals, fur bearers, and many of the game birds by wolves and by coyotes, which are extending their range in Alaska. The bureau expert detailed to the Territory for the purpose was able to work out satisfactory methods of attacking the problem. The Territorial legislature has appropriated $30,000 for the next biennium, and predatory-animal control will be carried on in cooperation with the Biological Survey, men trained in methods recommended by the bureau being employed to carry on control operations and to instruct native trappers and others interested regarding the best methods of destroying these pests.

Inability of the bureau to furnish hunters for work in all localities has led to a cooperative system in Wyoming, and to a less extent in Idaho and some other States, known as the farmer-hunter system, by which some type of service is possible for every responsible individual requesting it. Under this system a selected number of farmers and stockmen are given instructions and furnished with poison to work in districts that can not be covered by the salaried hunters, in this way supplementing to some extent the work of the regular force.

WOLVES AND COYOTES

The coyote is the most destructive animal on the western stock ranges, and also is a potential carrier of rabies and tularemia. Because of the menace of coyotes and the fact that when these animals are raised in captivity they frequently escape or are turned loose, the Oregon Legislature at its last session enacted a law prohibiting keeping them in captivity except in zoological parks. An outbreak of rabies among coyotes occurred during the year in the State of Washington, and to prevent serious losses additional hunters were

employed. Sporadic outbreaks of smaller proportions in Oregon, Nevada, and Colorado also called for control operations by field forces.

The gray wolf is no longer a livestock menace in States west of the one-hundredth meridian, although patrol work must be continued on the southern border of Arizona and New Mexico to prevent ingress of individual wolves from Mexico. The small red wolf of eastern Texas and adjacent territory, however, still commits serious depredations on livestock. The destruction of 1,043 of these predators in Texas during the year registers marked progress toward control.

An acute situation has arisen in Arkansas, particularly on the national forests, because of the increasing number of wolves there. Successful fire control on forest areas has permitted the growth of hardwood thickets dense enough to harbor the wolves and other predatory animals. On the Ouachita National Forest residents suffered such heavy losses of livestock from wolves that woods burning was considered as a measure to drive out the predators. In such cases there is need for quick and effective control operations so as to make recourse to forest burning unnecessary. In one district of the Ozark National Forest in 1927, wolves killed more than 1,600 hogs, pigs, sheep, and lambs, valued at $4,600, and inflicted similar losses in other areas.

Action tending to relieve the situation became effective at the beginning of the fiscal year, when a formal agreement for predatory-animal control operations was entered into between the bureau and the Arkansas State game and fish commission. Actual field work began in August, 1928, in connection with operations in Oklahoma, which were started at the same time, and during the ensuing 11 months 352 wolves as well as other predators were taken. As a result many letters of commendation have been received from farmers in the two States.

The total number of coyotes destroyed during the year, of which skins or scalps were actually obtained, was 40,254; the number of gray wolves, 71; and the number of red wolves, 1,339. In addition, it is estimated that 54,000 coyotes not recovered were destroyed by the use of poisons. Because of unusually deep snows and stormy weather during the fur season in many districts of the West, the percentage of pelts recovered this year was lower than usual.

MOUNTAIN LIONS

The Biological Survey and cooperative hunters disposed of 252 mountain lions during the year—28 in Utah, 9 in Oregon, 10 in Montana, 36 in New Mexico, 152 in Arizona, and 17 in other States. In Arizona the total number of mountain lions destroyed in 13 years totals 1,062.

BEARS

It became necessary in the course of the year to destroy 280 bears that had acquired the habit of preying upon livestock. Bears are not as a rule of predatory habits, but individuals that become stock killers must be destroyed. The policy of the Biological Survey is to establish the fact that an individual bear has become addicted to stock-killing before authorizing its capture. During the year it was ascertained that certain bears had become predatory in communities in Arizona, Colorado, Montana, Oregon, Washington, and Wyoming. Urgent requests also came from West Virginia for assistance in controlling bears known to be killing livestock, particularly sheep.

BOBCATS AND CANADA LYNXES

Bobcats and Canada lynxes are the cause of considerable loss in livestock, especially sheep, during the lambing season. They are destructive also to game birds and have been known to kill the young of big-game animals. During the year 5,419 bobcats and 46 Canada lynxes were taken in the States in which predatory-animal control operations were conducted. The destructiveness of bobcats to game in the Eastern States has been called to attention during the past few years, and the bureau has had numerous requests for assistance in controlling these animals from New Hampshire, Virginia, West Virginia, and elsewhere.

HOUSE CATS

House cats are frequently abandoned and their offspring forced to gain a precarious living, and under such conditions, reverting to wild habits, they become skilled hunters and thus are a most serious menace to valuable birds, rabbits, and other small beneficial forms of wild life as well as to poultry. Where stray cats are numerous in city, town, or rural communities they are often the most

common of the carnivorous animals, and it therefore becomes necessary to control them. To answer the many requests for directions on trapping stray animals, a manuscript entitled "How to Make a Cat Trap" was prepared for publication as a leaflet (No. 50) and was in press at the close of the year.

CONTROL OF INJURIOUS RODENTS

Injurious rodents are the cause of enormous losses in farm crops and range forage in the United States, and their denudation of lands through close cropping of native grasses is one of the primary causes of destructive erosion. Control of these pests is one of the most tangible means of increasing profits in agriculture, horticulture, stock raising, and forestry. Control is necessary over the entire United States, and requires not only action by Federal and State officials but voluntary cooperation of hundreds of thousands of farmers and others. The fact has been recognized for many years that cooperation and systematic effort on all infested areas are essential.

The Biological Survey, with the responsibility of leadership in rodent control, has enlisted the cooperation of many thousands of farmers and other landowners. This has resulted in the destruction of certain rodent pests on millions of acres of valuable agricultural land and has been attended by an enormous direct saving and by increased production of important crops.

The eagerness with which more than 99,000 farmers during the year availed themselves of the opportunity to obtain relief from these pests through cooperative action is most significant and gratifying. Farmers are coming more and more to realize that losses from rodent pests need not be tolerated.

Though the progress in controlling rodents on range and farm lands is gratifying, a serious infestation on Federal lands, particularly on national forests, should have immediate attention. The carrying capacity of grazing areas on rodent-infested national-forest lands, estimated at more than 8,000,000 acres, is reduced from 25 to 80 per cent by such rodents as prairie dogs and ground squirrels. Federal lands are frequently centers of infestation, and if rodents are not controlled there permanent relief on adjacent private property is impossible. The Federal Government has a moral obligation to take care of its own lands, and a comprehensive rodent-control program, more extensive than present funds permit, is called for.

Organized rodent-control operations were carried on during the year under the leadership of the Biological Survey in 27 States, and educational work in five others. While these operations were largely conducted in the Western States, the East was not neglected, and it is planned to carry on more extensive work east of the Mississippi River when resources become available. Arrangements were made for undertaking rodent control in Mississippi, Alabama, and Louisiana, beginning July 1, 1929.

In field operations 3,718,000 pounds of poisoned bait, 106,000 pounds of calcium cyanide, and 411,000 pounds of carbon disulphide were used in controlling the rodent pests on 19,425,000 acres of land. Of the strychnine used in preparing bait, 75,600 ounces were purchased through the bureau from the manufacturers at a saving to cooperators of approximately $40,000. This saving allowed more extensive use of the cooperators' available funds. Data compiled at the close of the year show that since the inception of this work by the bureau, rodent pests have been eradicated on 14,300,718 acres of land, or brought under control there to such an extent that no damage from them was sustained.

During the year the operation of a central bait-mixing station in the Idaho district demonstrated its usefulness. This station has made it possible for cooperators to obtain satisfactory bait uniformly mixed and available at all times in adequate quantities at the lowest possible cost. During the year 436,000 pounds of oats were specially processed by steam rolling, 170,000 pounds of which were used in the Idaho district and 266,000 pounds in other States. A good quality of bait has thus been made available for poisoning ground squirrels, prairie dogs, and field mice and a substantial saving effected both to cooperators and to the bureau in time and reduced cost of materials.

GROUND SQUIRRELS

Campaigns to control the depredations of ground squirrels were carried on in all States west of the Great Plains and in Kansas and South Dakota. In most cases losses in agricultural crops were thus kept at a minimum. In the Fremont National Forest in Oregon a heavy ground-squirrel infestation, together with a

serious drought, threatened complete loss of forage for livestock in that section. This was obviated by the control of the ground squirrels in operations conducted under the leadership of the bureau.

Prevalence of bubonic plague among ground squirrels in parts of California led to an emergency appropriation of $100,000 by the State of California for the destruction of rodents on plague areas, and to urgent requests that the Biological Survey take care of the Federal lands involved. The resources of the bureau would not permit treating all Federal lands in these areas, but every assistance possible was given in the way of organizing the work and making available to cooperators information on efficient methods of control.

PRAIRIE DOGS

Since the bureau began the control operations against prairie dogs a total of 10,553,618 acres have been cleared of these rodents, and enormous saving to the livestock and farming industries and the checking of soil erosion over large areas have resulted. In a 5-year program for the eradication of prairie dogs in Kansas approximately 150,000 acres of land have been reclaimed for stock raising. On the basis of an average grazing requirement of 7½ acres a head, the reclamation of this acreage of prairie-dog-infested land would make available additional forage sufficient to support 20,000 cattle annually. Similar conclusions may be drawn relative to areas cleared of prairie dogs in other States.

JACK RABBITS

Preliminary experiments conducted by the Biological Survey in Arizona have demonstrated that 12 jack rabbits will eat as much green forage as a 120-pound ewe sheep, and that 59 will eat as much as a 750-pound cow; in the consumption of dry feed (alfalfa hay), 14 will eat as much as a sheep and 71 as much as a cow. The control of jack rabbits in all the territory west of the Mississippi River is thus of great economic importance. These animals are responsible for a considerable loss in farm crops, particularly alfalfa, range grasses, and fruit trees. They also destroy cotton plants in the Southwest, and in the Northwest ruin large quantities of hay in stacks during the winter. Operations for their control conducted in 13 States during the year resulted in the protection of large crop and forage areas.

The assistance rendered by field men of the Biological Survey in finding a market for wild-rabbit skins, and in giving instructions as to their preparation for shipment, has not only been responsible to a large extent for a profitable return on efforts expended, but has added impetus to control operations. During the year more than 8,000,000 jack-rabbit skins were thus sold, at prices ranging from 15 to 45 cents each, bringing approximately $2,000,000 to cooperators in Arizona, Colorado, Idaho, Kansas, Montana, Oregon, South Dakota, Utah, Washington, and Wyoming. If the market for jack-rabbit skins continues to yield profitable returns, the problem of controlling the animals will be greatly simplified. An exhibit illustrating the various steps in manufacturing felt hats from the fur of wild rabbits and showing the value of the skins has been prepared to stimulate control efforts.

POCKET GOPHERS

Cooperative campaigns for the control of pocket gophers, carried on in 14 States, afforded protection to large areas of forage and grain crops and to fruit and forest trees, as well as to irrigation water. A 2-reel motion picture film, Million Dollar Pockets, graphically depicting methods of controlling pocket gophers, was used to advantage during the year in practically every State in which the bureau is conducting control operations. The film has stimulated much interest and is accomplishing results by bringing before the public the necessity of controlling pocket gophers.

The establishment of airports is presenting an additional problem in the control of pocket gophers. The burrows and mounds constructed by these rodents on landing fields are a serious hazard. During the year the bureau has received many requests from airport officials for assistance in the control of pocket gophers, and where possible these hazards have been removed.

Pocket gophers not only eat growing grain but cover much of it with soil. Their mounds prevent close mowing and interfere with and break the machinery. Their burrows in irrigation ditches and canals often result in costly breaks, wasting water and interfering with its distribution. In irrigated sections the animals also cause considerable soil erosion by digging burrows through which the irrigation water escapes and carries away the soil. In addition, they kill trees

in orchards and in forest plantings by gnawing off the roots. A manuscript for a technical bulletin, The Pocket Gopher and Its Relation to Man, was prepared during the year.

FIELD AND HOUSE MICE

Although in some years both house mice and several forms of field mice are scarce locally in the United States, in other years they increase to large numbers and inflict heavy damage to farm and orchard crops. A serious infestation of white-footed field mice occurred during the year in five counties of South Dakota. In these counties the bureau carried on cooperative campaigns in which more than 21,000 pounds of poisoned bait were used, resulting in the protection of 53,380 acres of crops, mostly corn. The corn thus protected yielded an average of 12½ bushels to the acre, with a market value of 40 cents a bushel. Areas on which operations were conducted were not seriously damaged by field mice, while on the comparatively few unprotected areas there was practically a complete loss. The saving in the corn crop alone as a result of this work amounted to about $250,000, and this was effected through the expenditure of less than 1 per cent of that sum. Compaigns for the control of field mice were also conducted in Arizona, Idaho, Oregon, Utah, and Washington, and, mainly for protection of orchards, in seven Eastern States. A report on the Buena Vista Lake mouse infestation of 1926–27, prepared in this bureau, was published by the California Department of Agriculture in October.

BROWN RATS

The brown rat constitutes a greater economic menace, both in spreading disease and in destroying property, than any other single mammal pest. Rat control in cities as well as on farms has been stressed through publicity in connection with organized antirat campaigns undertaken in 17 States, 60 being conducted in the East alone. The best methods of controlling rats in the Eastern States were brought to the attention of the public through demonstrations, lectures, and exhibits; in 307 demonstrations there was a total attendance of 7,606, and a comprehensive rat exhibit, shown at 22 different points, had a total attendance of 159,350. In addition, about 120,000 copies of Farmers' Bulletin No. 1533, Rat Control, were distributed throughout the United States during the year, and a motion picture, How to Get Rid of Rats, which was made under the auspices of the bureau, was shown in practically every district of the United States where rats are a menace. This has proved to be one of the most popular films released by the department.

WOODCHUCKS

Woodchucks become serious pests when they come in contact with agricultural crops and orchards. In the East they appear to be more numerous in cultivated fields than formerly. In control measures undertaken in four States calcium cyanide as a fumigant and also poisoned baits were used. Leaflet No. 21, Woodchuck Control in the Eastern States, has been widely distributed, and a motion picture, entitled "The Eastern Woodchuck and Its Control," was filmed during the year in cooperation with the Office of Motion Pictures of the department. This film will soon be ready for release and will be of material assistance in disseminating information on measures of control.

PORCUPINES

On one national forest in Colorado some 200,000 acres are so badly infested with porcupines that these rodents are alleged to be more destructive to the trees, including young plantings, than is any other single agency, fire not excepted. Similar conditions have been reported from Arizona, California, Idaho, New Mexico, Oregon, South Dakota, Utah, and Washington. During the past two years a simple but effective method of poisoning porcupines has been worked out by the rodent-control experts in the Western States. Extensive operations are needed over many of our national-forest lands. A manuscript, The Control of Porcupines in the Western States, has been prepared for publication as a leaflet.

SOIL EROSION CAUSED BY RODENTS

The subject of soil erosion is not adequately treated unless consideration is given to the influence of close cropping of grazing areas and burrowing by rodents. Prairie dogs, ground squirrels, and several other rodents prefer to live in the richer valleys and bench lands, and in obtaining their food in such places they often destroy the grass roots and denude the lands of vegetative cover, converting them into barren wastes and subjecting them to permanent damage by erosion. Many areas in the West that formerly supplied excellent forage for livestock have thus been rendered useless. The burrows of pocket gophers, woodchucks, and other rodents admit surface water and aid in washing deep gullies on sloping lands, thus per-

manently injuring them for agricultural purposes. Adequate operations for the control of injurious rodents materially decrease the extent of soil erosion.

ACQUISITION OF LANDS FOR REFUGES

MIGRATORY-BIRD REFUGES

On February 18, 1929, the President signed the Norbeck-Andresen Migratory Bird Conservation Act (45 Stat. 1222). This act may properly be considered one of the most important wild-life conservation measures that have ever been written upon the statute books of the Nation.

The new law is designed to supplement and give additional force and effect to the migratory bird treaty act of 1918, by providing Federal funds for the appraisal, purchase, and establishment of large areas throughout the entire country to be maintained as inviolate sanctuaries—feeding, nesting, and resting grounds—where migratory game birds may enjoy complete protection. The areas to be established will also serve as sanctuaries for hundreds of other varieties of wild life, including both game and nongame species.

From year to year there has been a constantly decreasing acreage of water and marsh area in this country, aggregating many thousands of square miles. In recent years it has become evident that close seasons, bag limits, and restrictions imposed upon the gunners will prove ineffectual unless suitable habitat of wild fowl is preserved. The passage of the new conservation measure is a national recognition of the great importance of the birds of North America as a food supply, as an incentive to healthful sport, outdoor study, and recreation, and as aids in the development of agriculture.

As authorized by the act, an appropriation of $75,000 was made available on July 1, 1929, for use in preliminary examinations and $5,000 additional for the expenses of the Migratory Bird Conservation Commission created by the act. In the following fiscal year (1931) the amount authorized to be appropriated is $200,000, and in 1932, $600,000, for surveys and the acquisition of lands for refuges. For the seven years following 1932 annual appropriations of $1,000,000 are authorized. At the close of this 10-year period it is anticipated that sufficient areas will have been procured to care for the more pressing and essential needs of the birds. Annual appropriations of $200,000 thereafter are authorized to pay the costs of maintaining the established refuges and patrolling them to protect the birds from poachers and predatory creatures, to control disease when possible, and to encourage the production of natural foods. It is contemplated that refuges will be established in suitable areas in every State of the Union. The key positions of the great system will closely follow the main migratory flight lines and concentration areas.

The approval of the Migratory Bird Conservation Commission must be had before any land purchase or lease may be consummated. The commission is composed of the Secretary of Agriculture, as chairman, the Secretary of Commerce, the Secretary of the Interior, two Members of the Senate, and two Members of the House of Representatives. To insure fullest cooperation with State governments, the ranking officer of the State game department, or in the absence of such department the governor or his representative, will serve as a member of the commission when areas proposed for refuge sites within his State are being considered.

Specific provision is made in the law that refuge areas may not be acquired in any State until that State shall have consented by law to the acquisition by the Federal Government of lands within the State. At the close of the year authority had been provided by special State legislation for the Federal Government to acquire lands for migratory-bird refuges in nine States—Kansas, Montana, South Dakota, North Carolina, New York, Missouri, California, Florida, and Illinois. In the following 17 States legislation already existing is considered to be sufficient to authorize the Federal Government to acquire refuge lands without further action of the legislatures: Arizona, Colorado, Connecticut, Georgia, Iowa, Louisiana, Maine, Maryland, Michigan, Minnesota, Nevada, New Mexico, Ohio, Oklahoma, South Carolina, West Virginia, and Wyoming.

It is necessary to ascertain, by examination, which of the numerous potential areas are biologically best adapted for refuges. Careful appraisals also must be made to determine the value of those tracts under consideration for purchase. Acceptances by the Secretary of Agriculture of gifts of land for refuge purposes are also authorized. The tasks of conducting the necessary biological investigations and of making the land-valuation surveys devolve upon the Bureau of Biological

Survey. A leaflet of preliminary information regarding procedure to be taken by persons having lands considered suitable and proposed for migratory-bird refuges (Bi–1018) was issued soon after the passage of the act.

This legislation and the program thereunder will put the United States in a position comparable with that already attained by Canada. That this action by the United States is considered equally beneficial to that country is evidenced by the following statement of Charles Stewart, Minister of the Interior, whose department is charged with the administration of legislation in Canada under the migratory bird treaty:

> Agricultural expansion and other developments in the southern United States, where most of Canada's waterfowl spend the winter, have gradually been encroaching upon the marsh lands there, and those interested in wild-life conservation in the United States have been trying for some years to find an adequate solution of the problem of providing these birds with suitable wintering marshes. Apparently the passage of the Norbeck-Andresen bill by Congress is the answer that has been sought. If the waterfowl are denied suitable wintering marshes they will become extinct in spite of all that Canada can do to protect them in summer, for birds go south in winter. Sportsmen and bird lovers of Canada will be delighted that this action has been taken under the migratory bird treaty by Congress, and that this bill provides for a series of inviolable bird sanctuaries in the South.
>
> With reference to the Dominion's action in this matter, I am happy to be able to say that Canada has reserved forty bird sanctuaries under the treaty, and in these the summer homes of seabirds on the coasts and of ducks and geese in the interior are protected. In addition to these sanctuaries 51 public shooting grounds have been set aside. These are great marshes where waterfowl nest safely during the breeding time, and which differ only from total sanctuaries in that shooting is allowed on them for a set time each fall.

UPPER MISSISSIPPI RIVER REFUGE LANDS

On the Upper Mississippi River Wild Life and Fish Refuge, a total of 87,900 acres of land had been taken under control up to June 30, 1929. In addition, there are 9,770 acres of State and city-owned lands adjoining that which is Government-owned. This acreage, together with the interlocking water areas, constitutes a total of approximately 156,000 acres of land and water now used for wild-life purposes on this refuge. Negotiations for the acquisition of the remaining land needed, constituting about 50,000 acres, are progressing as rapidly as conditions permit.

BEAR RIVER REFUGE LANDS

On the Bear River Migratory Bird Refuge in Utah, 15,860 acres of land were contracted for during the year, and under an act of Congress authorizing the exchange of lands contractual obligations have been entered into that will practically complete all land-acquisition negotiations on this refuge that are necessary. The fiscal year 1929 saw the completion of the engineering study designed to effect improvements required on the Bear River Refuge, such as dikes, ditches, and river-control works, and bids have been solicited for their construction.

MAINTENANCE OF WILD-LIFE RESERVATIONS

The year has brought a notable increase of public support for the refuge system as a means of restoring wild life in depleted areas. Refuges established on Federal lands and the development of the game-sanctuary idea in many of the States are strong indications that this method is becoming a prominent factor in wild-life administration. The mere acquisition of lands and their designation as wild-life sanctuaries, however, are not in themselves sufficient to obtain the results desired. In most instances where the sanctuary method has failed to fulfill expectations the cause will be found to be an absence of sound administrative plans or inadequate maintenance funds.

Without proper administration, many of the sanctuary areas have no more value as wild-life refuges than have adjacent unprotected lands. Under most conditions the successful administration of a refuge requires constant supervision. Game and food species must be protected against encroachment by poachers and often against such destroyers as forest fires. There are likely to be periods during which some predatory forms must be controlled. On the other hand, overabundance of the species to be protected may become a serious menace to their welfare, and arrangements must then be made to dispose satisfactorily of the surplus. On areas set aside as big-game preserves such surpluses result in overgrazing. Death from starvation and permanent injury to the range may be expected where overgrazing becomes serious.

NEEDS OF RESERVATIONS

As in former years appropriations for improvements on wild-life reservations maintained by the Biological Survey have covered only the most pressing necessities; additional funds are needed for proper maintenance. Full-time protectors are in charge of the big-game preserves, the Upper Mis-

sissippi River Wild Life and Fish Refuge, and a few of the more important bird refuges; some of the bird refuges also are policed at critical periods of the year by part-time protectors, but on others practically no protection has been possible with the funds available. It is imperative that more adequate policing and the necessary equipment for the purpose be provided for a considerable number of these reservations. Some of the big-game reservations should be enlarged to permit carrying fair-sized herds of pure strains of buffalo and other species of big-game mammals not yet properly provided for.

NEW RESERVATIONS

Three new reservations were established during the year: Nunivak Island in Bering Sea, off the coast of Alaska, set aside primarily for a reindeer experimental tract; Fort Keogh, Mont., embracing the 57,000-acre United States Range Livestock Experiment Station administered by the Bureau of Animal Industry, on which both waterfowl and upland birds will find suitable habitat and protection; and Tule Lake, Calif., a sump of 10,300 acres within the Klamath irrigation project, which serves as a retreat for waterfowl and shore birds and offsets to some extent the loss of sanctuary caused by the drying up of the lower Klamath refuge. An area of 2,800 acres in the southern portion is open to hunting during the shooting season, and the remaining 7,500 acres are reserved for strictly sanctuary purposes. Preliminary steps also have been taken for the establishment of a bird refuge on Cedar Keys, off the west coast of Florida; and under authorization of Executive order of June 20 preliminary plans were made for establishing an antelope range in Nevada in cooperation with the National Association of Audubon Societies.

BIG-GAME PRESERVES

The following big-game preserves are maintained by the Bureau of Biological Survey in the Western States: The National Bison Range in Montana; the Niobrara Reservation in Nebraska; the Sullys Hill Game Preserve in North Dakota; the Wind Cave Game Preserve in South Dakota; and the Winter Elk Refuge in Wyoming. The numbers of buffalo, elk, antelope, mountain sheep, and white-tailed and mule deer on the four fenced preserves (not including the Elk Refuge), and the increases in the herds, are shown in Tables 1 and 2.

TABLE 1.—*Big-game animals on reservations of the Bureau of Biological Survey, June 30, 1929*

Preserve	Buffalo	Elk	Antelope	Mountain sheep	Deer		Total
					White-tailed	Mule	
National Bison Range, Mont.	367	60	-------	100	[1] 32	[1] 139	698
Wind Cave Game Preserve, S. Dak.	174	[1] 98	25	-------	-------	-------	297
Sullys Hill Game Preserve, N. Dak.	13	31	17	-------	1	-------	62
Niobrara Reservation, Nebr.	106	[1] 115	9	-------	1	-------	231
Total	660	304	51	100	34	139	1,288

[1] Estimated.

TABLE 2.—*Young of big game born on reservations of the Bureau of Biological Survey during the calendar year 1928*

Preserve	Buffalo	Elk [1]	Antelope	Mountain sheep	Deer [1]
National Bison Range, Mont.	78	----------	----------	24	----------
Wind Cave Game Preserve, S. Dak.	41	----------	7	----------	----------
Sullys Hill Game Preserve, N. Dak.	4	----------	----------	----------	----------
Niobrara Reservation, Nebr.	12	----------	3	----------	----------
Total	135	----------	10	24	----------

[1] In the case of elk and deer it has thus far been impracticable to furnish definite figures regarding the young born.

NATIONAL BISON RANGE

Disposal of surplus animals on the National Bison Range, Mont., during the past winter became necessary as an emergency measure. To prevent excessive overgrazing, 427 elk, 151 buffalo, and 16 mule deer were removed. Of the elk, 213 were given to the State of Montana for stocking purposes; 49 were disposed of to private individuals, also for stocking or propagation; and 165 that could not be otherwise used were slaughtered for meat, chiefly for Indians on a near-by reservation. Of the 151 buffalo disposed of during the year, 4 were sent as gifts to various States; 5 were sold alive; and 142, for which there was no demand for propagating purposes, were butchered. The 16 mule deer were shipped alive from the range for sale, 10 to California and 6 to Texas. With a reduced number of animals on the limited range, the vegetation should now make good recovery and restore normal grazing conditions. The herd of mountain sheep maintained at the bison range has made a most satisfactory increase, and it is estimated that there are now about 100 of these animals on the reservation.

NIOBRARA RESERVATION

Lack of facilities makes it difficult to handle the surplus animals on the Niobrara Reservation in Nebraska. During the year, however, 4 buffalo and 9 elk were disposed of as dressed carcasses, and 3 elk were prepared as specimens for the National Museum at Stockholm, Sweden. Four antelope were born this spring and are in good condition, though there is a net loss in the band, as 7 died during the year, 3 of which were killed by bobcats.

The experiment in raising wild turkeys has not been wholly satisfactory. The natural conditions afforded on this range are favorable to their breeding and rearing the young, but because of their roving nature it is impossible to keep them within bounds, and consequently some are killed.

Heavy rains on the reservation resulted in a good crop of hay, of which 40 tons were shipped for use at Wind Cave Game Preserve.

WIND CAVE GAME PRESERVE

By completion of a big-game fence at the Wind Cave Game Preserve, S. Dak., the extent of the refuge was nearly doubled and a new pasture provided into which 77 buffalo were turned in May. The two big-game pastures now maintained are on opposite sides of the highway that passes through the National Park and Game Preserve, and the big-game animals may now be seen by passers-by. Negotiations were concluded during the year for an adequate supply of pure water for domestic and stock purposes.

The serious shortage of range forage last winter made it necessary to feed the big-game animals beginning on February 6. Approximately 42 tons of hay were purchased locally, and 40 tons were obtained from a surplus on the Niobrara Reservation, Nebr. Surplus stock disposed of during the year included 41 buffalo and 65 elk.

The dam across Cold Springs Creek, authorized by Congress, designed to impound water on the game preserve, was in process of construction before the end of the fiscal year and should be completed in the summer of 1929. Arrangements have been made to permit the State of South Dakota to widen the dam sufficiently to serve as a main highway connecting Hot Springs, the Wind Cave Park, the Wind Cave Game Preserve, and the Custer State Park and Game Preserve.

SULLYS HILL GAME PRESERVE

In order to restrict the herds of big game to the carrying capacity of the Sullys Hill Game Preserve, N. Dak., 7 buffalo and 10 elk were disposed of during the year. Progress was made in the establishment of an exhibition pasture, in which it will be possible to retain animals where they can be more readily seen by visitors. This reservation has become one of the favorite resorts for tourists and others interested in wild-life conservation, and during the year it was visited by 22,674 persons. Eight antelope were born in the spring, and all are in satisfactory condition. Improvements much needed in the water system supplying the headquarters and the public picnic grounds were nearly completed.

ELK REFUGE

About 6,000 elk of the southern Yellowstone herd were fed on the Elk Refuge, in Jackson Hole, Wyo., between February 5 and April 1. The winter was mild, and as the heavy snows of January and the first week of February melted early in March, the elk were able to forage on bare patches on the range. On a ranch 7 miles from Jackson, which was used by the State of Wyoming as a feeding

ground, about 300 elk were cared for, and nearly 300 tons of hay were left there after the feeding. The 195 tons of hay remaining on the Izaak Walton League addition to the refuge at the close of the previous feeding season were disposed of to the State at the first of the year. Later, 1,266 tons were harvested on the refuge, and this, augmented by 370 tons purchased by the State, was available for winter feeding. About 920 tons were used in the 56-day feeding period, leaving a surplus of 716 tons on refuge lands. The State has on hand approximately 450 tons, making a total of 1,166 tons on hand on June 30.

New farming equipment was obtained during the year, and this, together with additional labor, has made it possible to increase the hay acreage on the refuge, improve the stand, and decrease the quantity of squirreltail grass, which has been found to be injurious to the elk. With the new equipment the acreage cost of operations has been considerably reduced. To be prepared to care for an optimum herd of 20,000 elk, additional lands should be acquired for hay and pasture and to allow the animals easy access to the main refuge.

BIRD REFUGES

Eighty-two bird refuges are administered by the Biological Survey in the United States, Alaska, Hawaii, and Porto Rico, including the five big-game preserves, on which birds also are protected. A list of these and other national wild-life reservations (Miscellaneous Publication No. 51) was in press at the close of the year, and an article on the indispensable part that bird refuges play in saving wild life was published in the Yearbook of Agriculture, 1928, of the department. No adverse conditions have been reported on any of the refuges, and only a few require detailed comment.

BEAR RIVER MIGRATORY-BIRD REFUGE

Much of the preliminary work on the Bear River Migratory-Bird Refuge in Utah has been completed. It has been necessary to move slowly in the establishment of this great refuge, and considerable time, thought, and effort have been required to solve problems relating to land transfer and acquisition, surveys, and engineering work. The State legislature of Utah passed an additional enabling act early in the year to facilitate the establishment of the refuge, in which the Biological Survey has received the hearty cooperation of State officials, sportsmen, and others.

Migratory-waterfowl conditions on the refuge were satisfactory, and little duck sickness was in evidence at the close of the fiscal year. Many migratory birds nested on the refuge during the spring.

The completion of engineering construction will impound large bodies of pure, fresh water, and it is confidently expected that this additional supply will practically eliminate the danger of such large losses of wild fowl as have occurred on these marshes in the past.

SAVANNAH RIVER BIRD REFUGE

The Savannah River Bird Refuge, in South Carolina, is one of the most accessible of the bird reservations maintained by the bureau. A State highway traverses it, and passing tourists in great numbers are able to see the birds feeding in the marshes or flying over and across the sanctuary. Most of the area of this refuge is attractive to marsh-frequenting birds, and some young timber along the northern boundary should eventually furnish an excellent breeding place for the wood ducks of the region. The refuge has recently been posted with signs large enough to be seen from the road, advising the public of its character as a Federal bird refuge and that the birds are protected at all times. The available funds do not permit employing a reservation protector throughout the year, but patrol service has been maintained in seasons when the birds are present in greatest numbers.

LAKE MALHEUR BIRD REFUGE

The water supply at the Lake Malheur Bird Refuge, in Oregon, was more abundant during the summer of 1928 than in many recent years, but still far from adequate. The question of ownership of lands in the lake bed and its immediate vicinity continues to be a serious obstacle to the development of the refuge. Two bills were introduced in the last session of Congress to permit the State of Oregon and private individuals to sue the Federal Government to determine ownership and quiet title, one of which was passed by the House but failed in the Senate. It is hoped that legislation of this character may be passed at an early date.

ALEUTIAN ISLANDS RESERVATION

By Executive order of November 23, 1928, seven islands—Akun, Akutan, Sanak, Tigalda, Umnak, and Unalaska, including Sedanka—were withdrawn from the Aleutian Islands Reservation, Alaska, and restored to the public domain to be subject to the general land laws, because of their greater value for stock-raising than for wild-life purposes. The remainder of the reservation was supervised to the extent that the facilities permitted by the Alaska Game Commission in cooperation with the Biological Survey.

HAWAIIAN ISLANDS RESERVATION

The widely scattered units of the Hawaiian Islands Reservation present a difficult problem of patrol. The importance of keeping this extended sanctuary inviolate must be emphasized, as many rare birds frequent the islands, and some of the breeding colonies are subject to raiding by plume hunters. In the past the reservation has suffered seriously at times from the organized work of such poachers. Means should be provided to allow regular supervision of these islands. To do this effectively a patrol boat for the use of a resident protector is required.

The discovery of pearl-shell oysters at Pearl and Hermes Reef within the Hawaiian Islands Reservation was followed by the receipt of applications from several Hawaiian concerns for permits to carry on shell and other fishery operations there. In view of the bureau's lack of facilities for investigating conditions on the reservation or for supervising commercial activities there, a general order prepared in the Biological Survey was approved by the Secretary authorizing the governor of the Territory for the present to issue permits for the use and occupancy of the reef for these purposes.

UPPER MISSISSIPPI RIVER WILD-LIFE REFUGE

Increased attention has been given to the protection of the wild life of the Upper Mississippi River Wild Life and Fish Refuge, the area of which is being constantly increased. Beavers obtained in northern Wisconsin and Minnesota and released on the refuge are apparently doing well.

The experimental waterfowl colony maintained on Lake Winona, Minn., continues to develop with gratifying results. A considerable tract of marsh and shore along the lake, which was fenced by the city of Winona, makes it possible more adequately to protect the wild life therein. Approximately 500 ducks were hatched in this area during the spring. Half of these will be banded and released prior to the southern migration this fall, and their return next spring to nest on the refuge will be looked for.

There has been a decided surplus of muskrats on the refuge, and trapping under regulation has been permitted in a manner that appears to have been satisfactory both to the trappers and to the general public. Approximately 30,000 muskrats were taken and brought an average price of $2 each, the refuge thereby producing a revenue to the local public of about $60,000.

Pollution of the waters in the vicinity of the refuge has come from both city waste and the discharge from oil burners and tankers. This condition should be remedied. No serious fires occurred on the refuge during the year, as several that were started were immediately brought under control by prompt action on the part of the reservation rangers. The fire hazard in dry years, however, is serious.

RECREATIONAL USES OF WILD-LIFE REFUGES

Although wild-life reservations are established primarily for the preservation of the birds, mammals, and other native species, their existence in some instances is still further justified by the recreational opportunities they provide for the public. It is believed that this feature deserves development to the greatest extent possible consistent with the use of these areas as refuges for wild life. Each year increasing numbers of the American public visit the big-game preserves and certain of the bird refuges. The visitors compose all classes, from the student of wild life to those who have merely a casual interest. Facilities at these reservations are not yet sufficient to allow the public to enjoy them to the fullest extent possible. It is desirable that the big-game preserves be provided with roads, water, sanitary facilities, and other conveniences, and that, when necessary, guards and other personnel be employed to guide and control the movements of the visitors in order that they may observe the wild life under natural conditions without molesting it or being in danger themselves. These desirable results can be attained only by a series of improvements undertaken over a period of years.

ADMINISTRATION OF WILD-LIFE PROTECTIVE LAWS

Unquestionably the respect for Federal, State, and Territorial laws designed to afford protection to wild life is increasing. Though a larger number of cases was reported for prosecution in the courts during the fiscal year just closed and more jail sentences were imposed than in the previous year, this fact does not necessarily indicate actual increase in the number of persons wilfully violating the regulations. It may be taken to indicate, however, that public interest in the enforcement of laws for wild-life conservation generally is increasing and that, as a result, a greater mass of evidence is being placed in the hands of enforcement authorities, particularly as conservationists, sportsmen, and trappers are all interested in obtaining maximum returns from the administration of laws protecting big game, game birds, and fur bearers.

PROTECTION OF MIGRATORY BIRDS

Illicit operations by the market gunner, the spring shooter, and the night hunter are still conducted on a serious scale in some localities, but every effort commensurate with ability of a limited enforcement personnel is being made to curb these violations. That attempts to enforce the provisions of the migratory bird treaty act with only 23 full-time United States game protectors can not be wholly effective is obvious. The problem is becoming more serious as wilful violators become aware of the lack of an adequate force of protectors.

The United States game protectors form an important contact between the Bureau of Biological Survey and the general public, and they have manifold duties in this relationship outside the actual patrol work. They are called upon constantly to supply reliable information and advice pertaining to wild life and its conservation. They are at times required to make investigations of a semiscientific nature. They also are invited to attend gatherings of conservation organizations, and frequently appear upon the program. Their educational work has resulted in improved conditions and a better observance of the Federal law on the part of the younger generation. Such duties, while essential, are classed as secondary and are not permitted to interfere with the regular law-enforcement program.

There has been an insistent demand during the past year from State game officials and organizations engaged in wild-life conservation, and from individual citizens as well, for an extension of the law-enforcement activities directed by the Biological Survey. At present each United States game protector on the average must have within his patrol district an area approximately equal to two States. It is contended that if these patrols could be increased so as to permit the employment of one protector in each State, with necessary assistants, the beneficial results accruing would be beyond all proportion to the comparatively small additional expense involved.

The suppression of illegal practices in the taking of migratory birds in the United States does not offer obstacles that are insurmountable. Those that are encountered can be met and overcome by the employment of an effective and energetic force of game protectors, supported by favorable public opinion.

ASSAULTS ON PROTECTORS

There is urgent need for a Federal statute under which assailants of Federal officers may be adequately punished. The occupation of a game protector is hazardous work, and lack of protection in the performance of his duties not only diminishes the effective execution of the police powers conferred but provokes contempt for the law. Since the passage of the migratory bird treaty act, one Federal game protector has been killed while engaged in the enforcement of the regulations, two have been seriously injured, and others have been assaulted by persons whom they were attempting to arrest. In cases of such assaults redress can be sought only in local courts, where the results have proved unsatisfactory.

AMENDMENTS TO REGULATIONS

After consideration by the Migratory Bird Treaty Act Advisory Board, amendments were adopted by the department and approved by the President relating to the manner of issuing scientific-collecting permits, and to records and reports required of taxidermists concerning the handling of migratory birds; prohibiting the hunting of migratory game birds from automobiles; and changing open seasons on certain species, including mourning doves in North Carolina, Georgia, Louisiana, and Alabama; waterfowl in Illinois, Massachusetts, Missouri, Oklahoma, and east of the

Cascade Mountains in Washington; and woodcock in all States in which its hunting is permitted. The close season was continued on greater and lesser yellowlegs.

Many requests have come to the Biological Survey to allow limited shooting of swans, the plea being made that these birds were destroying wildfowl food plants in such quantity as to menace the future supply for other waterfowl. Investigations, however, have failed to show that swans do this to any greater extent than do other species of waterfowl. Most careful consideration has been given the matter, since an error at this stage might very well result in the total extermination of rare and valuable species. The complete protection enjoyed by swans throughout this country has been continued for the reason that the total number of the trumpeter and whistling swans combined is not large and that irreparable damage would result if shooting were permitted, as the average gunner can not distinguish between the two species. A plea was made through the press for the sympathetic consideration of all sportsmen, "in view of the rather precarious condition of the whistling swan and the still more dubious situation of the trumpeter swan." Swans enjoy similar protection in Canada, under the terms of legislation protecting birds that migrate between the two countries.

LAW VIOLATIONS AND PENALTIES

The handling and disposition of cases of violation of the migratory bird treaty act during the year are shown in Table 3. Because of impositions of adequate fines in State courts, youthfulness of offenders, lack of sufficient evidence, or other satisfactory reasons, 78 cases reported by United States game protectors and United States deputy game wardens were not forwarded for prosecution. Federal judges imposed fines ranging from $1 to $500, aggregating $13,368.95, and jail sentences in 27 cases. Defendants were placed on 6-months' probation in two cases, and jail sentences of 6 months each were suspended in six others, as was one 60-day sentence. One defendant was sentenced to 10 days in jail, 18 to 30 days in jail, and 1 to 6 months. Plumage and migratory game birds of an estimated market value of $2,500 were confiscated. In the majority of instances the game birds seized were donated to hospitals and other charitable institutions for use as food, the plumage being utilized for scientific and educational purposes.

Since the passage of the Upper Mississippi River Wild Life and Fish Refuge act, 11 violations of that law have been reported for prosecution in Federal courts. The first two of these terminated in fines of $25 each, and the remainder are still pending. Reservation wardens apprehended 23 persons violating State game laws on the refuge, 16 in Minnesota, and 7 in Wisconsin. All these cases were terminated by fines, totaling $870. Three defendants who defaulted were required to serve jail sentences of 12, 60, and 90 days, respectively.

Under section 84 of the United States Criminal Code protecting wild animals, birds, and birds' eggs on Federal refuges, 9 new cases were reported for prosecution in Federal courts; of these, 2 were dismissed, 4 were closed by fines of $10 to $25 each, and the remainder are still pending.

PERMITS TO KILL INJURIOUS BIRDS

It had not been necessary for several years for the Secretary to issue an order to permit the killing of wild ducks to prevent serious injury to agriculture or other interests. This year, however, at the urgent request

TABLE 3.—*Cases of violation of the migratory bird treaty act handled during the fiscal year 1929, and disposed of or still pending*

Cases	Number	Disposition of cases	Number
Pending from former year	386	Convictions	399
New cases reported	576	Dismissals	39
		Verdicts of not guilty	11
Total	962	No bills found	9
		Nolle prosse	46
Disposed of	508	Death of accused	4
Pending at end of year	454		
		Total	508

of the Kansas State game and fish warden, and in order to prevent serious depredations to grain that had not been harvested, an order was signed by the Secretary on January 18 allowing landowners and their bona fide employees, when acting under permits countersigned by the State game authorities, to shoot wild ducks at any time. After the issuance of the order methods of control were adopted that proved successful in frightening the ducks from the fields. The grain was thus protected without the necessity of killing the birds, and no permits were actually issued under the order.

PERMITS ISSUED

To allow the possession of certain migratory birds for legitimate purposes during the close seasons, the migratory bird treaty act authorizes the issuance of permits for making collections for scientific purposes, including bird banding, for possession by taxidermists, for propagation, and for certain other purposes. During the year such permits were issued as follows: Scientific collecting, 204, making the total number outstanding, 1,789; scientific possession (taxidermists), 27, bringing the total to 335; special possession, 101, total 570; propagation (possession and sale) 638, total, 3,874; bird banding, 227, total, 1,552; taking for propagation, 101. Reports on operations under permits are required to be made each year, and when they are not forthcoming the permits are revoked or canceled. Permits surrendered for cancellation or revoked during the year numbered 591.

The reports filed show that during the year 47,772 waterfowl of species protected by the migratory bird treaty act were propagated in captivity. The greatest numbers were mallard ducks (42,727), wood ducks (551), and Canada geese (3,973). Others being propagated under permit in small numbers were pintails, teals, widgeons, gadwalls, shovelers, and brant. Stocks disposed of by propagators consisted of 16,987 ducks for food and 8,947 as breeding stock, and 379 geese for food and 3,060 for propagation.

INTERSTATE COMMERCE IN WILD BIRDS AND MAMMALS

Since the features of the Lacey Act of 1900, as amended in 1909, relating to the interstate transportation of wild birds were superseded by broader provisions of the migratory bird treaty act of 1918, the application of the Lacey Act has been limited to interstate traffic by common carrier in the dead bodies or parts thereof of wild animals killed within, or transported from, a State illegally. Thus shipments of carcasses of wild animals by parcel post, properly marked as to contents, and their transportation by private carriers are not prohibited. Each season's operations demonstrate more clearly the need of amendments to the Lacey Act to apply to interstate transportation in any manner, and of further amendments to confer upon Federal officers police powers to seize illegal shipments and return them to the State from which they originated or in which the violation occurred, or to dispose of them on behalf of the State.

No Federal prosecutions have been instituted during the fiscal year for violations of the Lacey Act, although the investigations and activities under its provisions probably have been more extensive than during any similar period for the past decade. Most of the investigations were concerned with the skins of fur-bearing animals. Violations of the Federal law are predicated upon infractions of State laws. Federal investigations of such cases frequently disclose that State laws have been violated, although the evidence is insufficient for instituting Federal prosecutions. Federal action is largely dependent upon the nature of a State's legislation governing export shipments, and the fact that in many cases a State's legislation is defective in some respects precludes Federal prosecution and thus deprives the fur animals of that State of much of the supplemental protection that otherwise would be afforded them under the Federal legislation.

Field employees of the Biological Survey have conducted extensive investigations at raw-fur centers, and the information discovered relating to 4,500 apparently illegal shipments was transmitted to the game officials of the States affected. Reports received during the year indicate that approximately 2,000 such cases were actually violations of State law, and of these, 500 were closed without prosecution, because of youth of the violators, misunderstanding of the laws, or various other reasons. In the 1,500 cases prosecuted in State courts, fines and costs aggregating $37,838.75 were imposed and in addition in 11 instances jail sentences ranging from 10 to 60 days (aggregating 275 days). Seized skins illegally taken netted $667.50 in one State and $210 in another. In three other States skins of 56 beavers,

135 muskrats, and 12 minks were confiscated.

FEDERAL AND STATE COOPERATION

State game officials have expressed their appreciation of the cooperation of the Bureau of Biological Survey in furnishing information concerning illegal interstate shipments of wild birds and mammals or other infractions of State wild-life legislation. This cooperation has contributed substantially to the upbuilding of a wholesome respect for game laws as well as materially increasing the amount of fines collected in State courts. Through a slight reorganization the bureau is in position to increase this line of cooperative work and to render the States even more effective service.

State game officials have continued their cooperation with United States game protectors in the enforcement of Federal wild-life legislation. Closer and more effective cooperation has been effected by the wide distribution of publications prepared by the Biological Survey. Among these were the twenty-ninth annual Directory of Officials and Organizations Concerned with the Protection of Birds and Game (Miscellaneous Publication No. 30); the annual game-law bulletin for 1928–29 (Farmers' Bulletin No. 1575) of which 350,000 copies were distributed; the annual fur-law bulletin (Farmers' Bulletin No. 1576) (100,000 copies); two pamphlets (S. R. A.—B. S. 70 and S. R. A.—B. S. 71) containing the text of the treaty between the United States and Great Britain for the protection of migratory birds, of the Lacey Act regulating interstate commerce in game, and of other Federal laws and regulations pertaining to the protection of wild life; and the annual poster (No. 47–Bi) showing the open seasons for hunting game throughout the United States, Canada, Alaska, Newfoundland, and Mexico. The poster is of special importance because it is published immediately after the adjournment of the State legislatures making changes in the open seasons and is generally the first available printed information relative to such changes. It is sent to postmasters and others in important wild-fowl States, and is not only thus placed conspicuously where all may obtain the information, but is republished in full by numerous outdoor and sportsmen's periodicals.

Statistics relative to hunting licenses issued by the various States for the season 1927–28 and compiled by the Biological Survey show that there were more than 6,450,000 licenses issued and that they returned to the States a revenue of more than $9,300,000, mostly for use in game-protection work. Similar data for the previous season were published in the 1928 Yearbook. These figures, for many States, cover combined hunting and fishing licenses.

IMPORTATIONS OF FOREIGN BIRDS AND MAMMALS

The close of the fiscal year marks the completion of 29 years of regulation by the Bureau of Biological Survey of importations of birds and mammals from foreign countries, and the bureau is now entering the closing year in the third decade of governmental supervision of entries, an experiment conducted on a more extensive scale than has ever been attempted by any other country.

Nearly 10,000,000 birds and a large number of mammals have been imported since 1900, but so far as known during this time no injurious species not previously imported has obtained a foothold in the United States. The English sparrow and the European starling were already here; and the crested Chinese starling, which has gained a foothold in British Columbia, has not yet crossed the line. Some years ago Canada adopted restrictions modeled after the laws of the United States regulating the importation of foreign birds and mammals, and in some respects these restrictions are even more stringent than those in force in this country, so that the danger of entry of foreign species from the north has been largely removed. Importations from the south, particularly those coming through Mexico and Cuba, require vigilant supervision and may necessitate more effective regulation in the near future. The experiment in which the United States has been engaged has demonstrated the possibility of preventing the introduction of species injurious to agriculture, in spite of the great extent of the country's boundaries and the enormous increase in importations.

Notwithstanding the constant influx of foreign birds and mammals the United States has actually gained relatively few species. The Hungarian partridge has been successfully introduced and has become sufficiently acclimatized in several Western States to permit short open seasons for hunting in some sections. The Chinese

dove has become locally acclimatized at Los Angeles, Calif. The true Mongolian pheasant has been introduced in some numbers, and the supply of Old-World pheasants, formerly obtained from abroad, is now furnished chiefly from birds bred in this country, either on State or on private game farms. The supply of quail, formerly obtained from the Southwest, is now derived solely from the States of northeastern Mexico, and importations have increased to nearly 87,000 a season, The demand for aviary and cage birds has increased the importations to the point where these birds average nearly a thousand a day, but most cage birds except parrots are short-lived; some live only a few weeks, and the majority probably do not survive on the average more than three years.

The number of importation permits issued during the year was 1,254, an increase of 43 over that of the preceding year, and inspection of shipments at ports of entry increased from 441 to 510. In addition, 19 permits were issued at Honolulu, Hawaii, for the entry of 637 miscellaneous birds. The importation of birds was the largest since the issue of permits began. Of the total number brought in, more than two-thirds were cage birds, and more than half were canaries. Game birds included less than a third of the total number, and chiefly comprised Mexican quail and Hungarian partridges. Importations included 28,517 Hungarian partridges, 8,061 pheasants, a few waterfowl, and many miscellaneous birds. The total number of foreign birds imported was 825,486, of which 12,603 were without permit, being mainly brought in under declaration of passengers' baggage. The importations under permit consisted of 589,251 canaries, 57,098 parrots, 87,131 quail, and 79,403 representatives of miscellaneous species.

MAMMALS

Mammals imported under permit consisted chiefly of foxes, muskrats, and bears, with a number of other species intended largely for exhibition. Comparatively few fur-bearing animals except foxes and muskrats were brought in.

The number of foxes imported from Canada, which numbered 1,091, showed a marked decrease from the previous year, 3,044. Evidently fox farms in the United States are now supplying most of the breeding stock required.

During the summer and early fall there are frequent demands for permits to import black bears from Canada. Most of these bears are cubs brought in from the Provinces of Manitoba, Ontario, and Quebec, intended for exhibition in parks and zoological gardens. The entry of these animals indicates a regular market for young bears, notwithstanding that a number of surplus animals are distributed each year from certain of the national parks in the West. Applications are made for permits to import mountain lions, wolves, coyotes, and wild cats at points along the Mexican border, also evidently for exhibition purposes. Notwithstanding the number captured in campaigns against predatory animals, the present demand for exhibition stock apparently can be supplied more cheaply by importation than by the capture of animals in remote parts of the West.

Among the rare animals imported during the year was a Guadalupe Island fur seal (*Arctocephalus townsendi*) for exhibition in the San Diego, Calif., Zoological Park, the only specimen of its kind in the United States; two Siberian snow leopards (*Felis uncia*), and four gorillas. Two of the gorillas died within a few months after arrival, and the other two were placed on exhibition, one in the National Zoological Park, at Washington, and the other in the New York Zoological Park. Other rare species were brought in for zoological gardens and for traveling menageries.

GAME BIRDS

Mexican quail.—Preparations were made for the receipt of the largest number of quail ever brought in from Mexico, and concessions were granted by Mexican authorities to four exporters, three of whom operated as heretofore at the ports of Brownsville, Laredo, and Eagle Pass, Tex. The number of quail actually imported was 87,131, or about 2,000 more than in 1926, the year that previously held the record. Of these, 28,718 were entered at Brownsville, 45,000 at Laredo, and 13,413 at Eagle Pass, destined chiefly to Alabama, Kansas, Kentucky, Maryland, Oklahoma, Pennsylvania, Texas, and Virginia. The supervision of importations at the border was conducted through cooperation with the Bureau of Animal Industry, whose inspectors issued the permits, examined all entries before reshipment, and furnished weekly reports on the number of quail entered and details as to their destination. No quail disease was reported during the season.

Other game birds.—Much interest has been displayed during the past two or three years in the importation of Hungarian partridges. Since this species has been successfully established in several Western States, others have sought to obtain breeding stock to build up their game resources. New York has been particularly active in this respect, and during the year has received several large shipments. The supply of birds is obtained chiefly from Czechoslovakia and Hungary, and the demand has been so great as to cause apprehension as to the source of supply. Early in the year shipments from Czechoslovakia were suspended for a time because of the disastrous effect of the cold winter on the stock of native birds. In addition to exporting 90,000 to 100,000 dead partridges annually, Czechoslovakia exports a large part of the live birds entered in the United States, England, and Switzerland. Many of these birds are bred solely for the export trade, and the prices vary from $1.76 to $2.94 each, to which is added a 25 per cent ad valorem export fee. Several shipments of pheasants were imported from Europe, chiefly to introduce new blood into the stock in the United States. A limited number of grouse, chiefly ruffed and sharp-tailed grouse, were entered from Alberta, and nearly 500 diminutive button quail (*Excalfactoria lineata*) from the Philippines and Australia, and 40 tinamous (*Nothura maculosa*) from southern South America.

CAGE BIRDS

The continuing demand for birds for zoological gardens, aviaries, and the retail trade has developed in the United States probably the largest market for cage birds of any country in the world. Statistics for foreign countries are lacking, but in the United States evidence seems to show a continually increasing demand, already large in volume. Most of these birds are canaries raised in captivity, mainly in Germany, but a few come from the Orient, chiefly China and Japan; and next in importance are parrots. The variety of miscellaneous birds brought in is very great, and the demand for rare species for private aviaries and a few of the zoological gardens stimulates importers to search the most remote corners of the earth for desirable species. Some of the private collections now maintained in the United States are remarkable both in their size and variety and compare favorably with some of the larger public collections.

An unusual number of rare species were imported during the period covered by this report. One of the largest consignments was that obtained by the expedition sent to New Guinea by the New York Zoological Society, which brought back about 220 birds, including 9 kinds of birds of paradise, among which were 16 Lawes's 6-plumed birds of paradise (*Parotia lawesi*), 2 long-tailed birds of paradise (*Epimachus fastosus meyeri*), 1 Hunstein's bird of paradise (*Diphyllodes magnificus hunsteini*), and 3 horned manucodes (*Phonygammus keraudrenii jamesi*); there were also several rare pigeons, among which were 1 white-throated pigeon (*Columba vitiensis halmahcira*), 7 golden-headed fruit pigeons (*Sylphitreron ornatus gestroi*), 1 superb fruit pigeon (*Ptilinopus superbus superbus*), and 8 Stephanie's pigeons (*Chalcophaps stephani*). Among other notable arrivals of the year were a number of emperor starlings (*Cosmopsarus regius*) from Africa, 3 Fiji shining parrots (*Pyrrhulopsis splendens*), 7 Palawan peacocks (*Polyplectron nehrkorni*), 10 blue-crowned hanging parrakeets (*Tanygnathus luconensis*), 20 Kea parrots (*Nestor notabilis*), 2 Forsten's lories (*Lorius forstenii*), 2 black-tailed Australian parrakeets (*Polytelis melanura*), 7 Cassin's doves (*Leptotila cassini*), and a pair of red-breasted geese (*Branta ruficollis*) from Asia. These geese are chiefly interesting because they form the subject of one of the earliest drawings of birds, made nearly 5,000 years ago and found on the walls of an Egyptian tomb. A considerable demand exists also for such ornamental birds as swans, of which a large number are imported each year. One consignment this year included 152 European swans, and another 500 black swans from Australia. These birds are in great demand for parks, as the native species of American swans do not breed in captivity.

WILD-LIFE CONSERVATION IN ALASKA

Prior to the enactment of the Alaska game law of 1925 Alaska's fur and game had been administered under separate and inadequate laws. The stocks of all fur bearers and of some of the game species had been considerably depleted, and many had been so far reduced as to threaten their existence locally. A serious situation

was thus presented, for Alaska's big-game and fur mammals and its bird life rank among the most important of the natural resources of the Territory, and there are few sections that do not produce one or more of these valuable forms. Throughout most of the Territory trapping is one of the chief industries, and in large sections a human population could scarcely exist without reliance upon the native game animals and birds for food.

The Alaska Game Commission created by the new law has realized the importance of gaining public support for game and fur protective measures and has on all occasions emphasized the fact that the maintenance of an abundant supply of wild life is advantageous from every standpoint. It has also shown that under wise management large areas that would otherwise be unproductive can be made to produce indefinitely valuable annual crops of fur and game. The soundness of these principles has been very generally recognized, and giving them publicity undoubtedly has been an important factor in the splendid response to the program of better wild-life protection. The five members of the commission are residents of Alaska, and one, the administrative officer, is the chief representative of the Bureau of Biological Survey in the Territory. Administration of the law has been carried on by the commission with an exceedingly limited personnel, but it has been well supported by those interested in the development of Alaskan resources. Little opposition to its law-enforcement activities has been voiced; on the contrary, there are constant demands that more adequate wild-life protective measures be undertaken. Prosecutions of violators have resulted in an exceptionally high percentage of convictions, and substantial fines and jail sentences have been the rule. As a result, the sharp decline in wild life has been checked, and some forms are already being gradually restored.

The fact that the three Territorial legislatures meeting during the past six years have made substantial appropriations for the stocking of areas with valuable species of wild life evidences the progress being made in the development of conservation measures. The stocking program has been concerned primarily with transferring to suitable areas valuable species that are native to the Territory, such as beavers, muskrats, and other fur bearers, deer and other big game, and blue grouse, and also with the importation of buffalo and elk. Reports indicate that the herd of 23 buffalo shipped last year from the National Bison Range in Montana through the cooperation of the Biological Survey thrived on the natural food of the region and came through the winter in good condition. All but four of the buffalo were liberated in a favorable region not far from Fairbanks, and these four were placed at the reindeer experiment station maintained by the Biological Survey at College, where they could be kept under close observation.

Special investigations also were made by representatives of the Biological Survey and the Alaska Game Commission regarding big brown and grizzly bears in the Territory, particularly those of the Kodiak-Afognak Islands group of southern Alaska. Petitioners had cited the growing agricultural activities of these islands and the losses suffered by stock raisers through the depredations of the Kodiak bear, and had asked that all protection be removed from these giants of the wild so as to permit persons to kill them in any manner at any time of year. In line with the policy of the department on predatory-animal control, which, while designed to safeguard farming and stock raising, is opposed to the extermination of any of the interesting species of the wild life of the continent, new regulations were approved to give protection as formerly to these big bears as game animals, but with the proviso that on Kodiak, Afognak, and certain other islands residents engaged in agriculture may kill them when they are considered a menace to persons, livestock, or property. This has the effect of preserving in nonagricultural mountain areas what is known to scientists, sportsmen, and visitors to Alaska to be the largest carnivorous land mammal in existence. Had all protection been removed from this notable animal, thus opening the way for its eventual extermination, a heavy fire of justifiable criticism would have come not only from the many organizations and individuals who have in the past derived both sport and pleasure from their contacts with the Kodiak bears, but from the people of Alaska generally, for the big-game animals form a notable feature of

Alaska's wild life and also attract from the States and other countries many visitors whose expenditures for equipment, travel, personal services, etc., constitute what is by no means an inconsiderable contribution to the commerce of the Territory. The Biological Survey, through the Alaska Game Commission and the Office of Experiment Stations of the department, will keep in close touch with the situation to note further developments. The new regulations, together with other laws and regulations relating to land fur-bearing animals and birds in the Territory, were published as a circular (No. 6) of the Alaska Game Commission.

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REPORT OF THE CHIEF OF THE BUREAU OF CHEMISTRY AND SOILS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF CHEMISTRY AND SOILS,
Washington, D. C., September 3, 1929.

SIR: I have the honor to submit herewith the report of the work of the Bureau of Chemistry and Soils for the fiscal year ended June 30, 1929.

Respectfully,

HENRY G. KNIGHT,
Chief of Bureau.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

INTRODUCTION

The Bureau of Chemistry and Soils serves the producers and consumers of farm products and the manufacturers who convert these products into articles of commerce. Primarily a research and fact-finding organization, the bureau has as its objectives the gathering of information and the determination of scientific facts and principles through experimentation and research, to the end that these may be applied to the conservation of American soils and to crop-production and crop-utilization problems of national or regional importance.

The work of the bureau covers a wide range of subject matter pertaining to land utilization, soil fertility, fertilizer-resource development, and the utilization of agricultural products of various kinds. Within this organization are the soil survey, which is mapping soil areas and laying the foundation for the study of the Nation's soil resources; soil-erosion studies, which aim to aid in reducing losses from soil washing and in controlling flood water; soil-fertility studies, having for their purpose a better utilization of the soil; and finally the application of engineering and chemical technology to the study of fertilizer resources and the more economical and diversified utilization of the products of the soil.

The research work now in progress includes investigations in soil chemistry, soil physics, soil erosion, soil microbiology, soil fertility, nitrogen fixation, potash and phosphate resources, crop chemistry, fruit and vegetable chemistry, fermentation methods for the production of organic acids, the utilization of farm and industrial wastes, food microbiology, food deterioration and spoilage, dust explosions and farm fires, and improvements in the technic of producing sirups, sugars, vegetable oils, proteins, insecticides, fungicides, tanning materials, and a variety of other products.

For the purpose of administration three large units are recognized within the bureau: (1) Chemical and Technological Research, (2) Soil Investigations, and (3) Fertilizer Resources and Fixed Nitrogen Investigations. Each of the three units is under a chief scientist who not only directs the work of his unit but also serves as a member of an informal coordinating board within the bureau. By virtue of its broad field of activities and the coordinated effort within the bureau the organization is given the opportunity to attack problems along very broad lines.

The Bureau of Chemistry and Soils is actively prosecuting investigations and research upon 376 subprojects under 122 major lines of inquiry recog-

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nized as projects. The major lines of inquiry to all intents and purposes are continuous or at least cover a period of years, while the subprojects, which represent the detailed activities of the bureau at any given period, have time limits placed upon them and when they are completed are succeeded by others usually in the same major line of inquiry.

In the main the appropriations are made to the bureau for the purpose of attacking specific problems, the solution of which is of interest to the business of agriculture and has therefore a utilitarian objective. However, direct attack upon some of these problems in the absence of essential fundamental knowledge is wasteful of funds and energy. Search for the necessary fundamental knowledge frequently leads the investigator into the realms of pure science, where a foundation is laid for the logical attack and final solution of the problem under consideration. Such a method of attack requires careful, thoughtful planning, the development of skilled technic, an intelligent and discriminating analysis of results, and ability of a high order to make the necessary practical applications.

The interest of the farmer should not terminate with the production of his crops, but he should be in a position to follow his products through to the ultimate consumer in order that he may intelligently adjust his production to the demands of the market. The Bureau of Chemistry and Soils, therefore, needs to function not only as a research agency to increase efficient unit production but should also be in position to follow the products of the farm through the industrial processes that make use of agricultural products.

The research activities of the bureau should result in a more economical utilization of farm products in the manufacture of articles of commerce and the production of more uniform final products, thus benefiting the farmer and the ultimate consumer. The widening of markets for farm products through the development of new channels for their industrial utilization is one of the most important functions of the bureau. This may be brought about only through painstaking research and the application of the results to the problems of industry. During recent years great strides have been made by the Nation as a whole through the development of new industries using as their raw materials the products of agriculture. The utilization of agricultural wastes and residues by industry is a subject which is receiving careful attention. The possibilities in this field appear to be very great. The wastes of to-day become important raw materials for the use of industry to-morrow. Numerous examples may be cited where waste has been converted into valuable commodities, but the greatest agricultural waste, the crop residues, consisting of stalks, straw, hulls, etc., are still awaiting wide industrial uses.

Something over one-half of the agricultural land area of the United States has been surveyed by the bureau. Land classification and effective land utilization upon sound principles await the completion of detailed and reconnaissance surveys of the remainder of the land area. Further, much of the soil-research work of the bureau is based upon the soil survey. There is an increasing interest on the part of the States in the whole subject of land classification, soil conservation, and soil fertility, which makes this field of work exceedingly important.

Results obtained in fertilizer and fixed-nitrogen investigations are being applied by industry as rapidly as conditions appear to warrant, thus reflecting direct benefit to agriculture in the form of cheaper and more satisfactory sources of plant-food materials. Advancement in this field depends largely upon the development of fundamental research and the application of the laws and principles thus discovered or verified to the technic of manufacture. Such researches are primarily functions of the Federal Government since they are directed to the development of a more efficient national agricultural program. At the present writing the nitrogen-fixation industry seems to be making satisfactory progress. The phosphate industry has been very well stabilized, based upon well-known practical methods, but new methods are being developed and put into use which will have a direct bearing upon the concentrated-fertilizer industry. Although the United States has rather large resources of potash, most of it is locked up in such form that it can not be made readily available. By an act of Congress at the last regular session funds were made available to the Bureau of Chemistry and Soils and to the Bureau of Mines for the purpose of making special investigations in an attempt to perfect commercial methods

for extracting potash from potash-bearing silicates, which are widely scattered over the country.

With the increased use of fertilizers in the agriculture of the United States, it is highly important that this country not only have sources of supplies of the raw materials, potash, phosphate, and nitrogen, but also that the most economic methods be developed for their preparation in satisfactory forms for use upon the land. Toward these objectives the fertilizer work of the bureau is steadily and effectively directed.

A total of 48 departmental publications from this bureau has been printed during the past year, including soil-survey reports, technical bulletins, farmers' bulletins, and circulars. In addition, 35 articles on the work of the bureau have appeared in the Yearbook of Agriculture, 1928. The number of soil surveys published during the year was more than double the number issued during the fiscal year 1928. This brings the published soil surveys much nearer current than has been the case for several years, but there is still need to bring the reports sufficiently up to date to meet the demand from all parts of the United States for prompter publication of the results of the soil surveys.

During the year 147 articles by scientific workers of the bureau have been published in technical and scientific journals, magazines, and other publications, giving other scientists and the public the latest information on the progress of various lines of work and research carried on by the three units of the bureau.

With the realization that its scientific work should be clearly reported to the public, by whom it is supported, the bureau in the past year has greatly increased its output of information to the press. Several hundred releases of timely interest have been prepared in the editorial office of the bureau and distributed through the press and radio services of the department to the special or regional groups to which they might prove of service.

CHEMICAL AND TECHNOLOGICAL RESEARCH

C. A. Browne, *Chief*

CARBOHYDRATE INVESTIGATIONS

CANE SIRUP

Experiments on methods of obtaining more profitable utilization of low-purity cane juice in sugar factories have been continued, with encouraging results.

These experiments proved that it is possible to make a sirup from a low-purity cane juice suitable to blend with corn sirup in the production of various grades of mixed sirups. By producing sirup instead of sugar from a low-purity last mill juice and preserving the juices of higher purity for sugar production it is possible that beneficial economies will result. Work in cooperation with a large sugar factory in Louisiana also proved that a good grade of sirup can be made by a process of combining the low-purity juices with one of the intermediate refinery products.

Substantial progress has been made in the investigation of "swells" in cans of sirup caused by a slow chemical reaction. Investigations indicate that the reaction between amino acids and reducing sugars, normal constituents of the juice, is partially responsible. The investigation is being continued to determine the other causes.

"Cane cream," a new product, developed by this bureau from sirup of low-purity juices, has been established on a production basis, and practically all technological problems of production and packaging have been solved. The work on cane sirup and cane cream is part of the general plan for the production of specialties which it is believed will benefit the Louisiana sugar and sirup industries and is directly in line with the bureau's program of developing commercial uses for agricultural by-products.

DIRECT-CONSUMPTION SUGARS

On the basis of information obtained, it is planned to conduct an investigation for the purpose of studying and improving juice clarification in connection with production of direct-consumption sugar and edible molasses, giving attention to the use of carbon in connection with the sulphur-lime process. It is possible that better grades of molasses may be produced without reducing sugar yield. This is part of the program for diversification of Louisiana sugarcane products and production of specialties particularly suited to the domestic cane-sugar industry of Louisiana and Florida.

Improvement in the quality of direct-consumption sugars is a matter which is now of very great interest to producers. Very small proportions of impurities derived from the juice have a

detrimental influence with regard to use in certain industries—for instance, in the candy industry. Many direct-consumption sugars give a poor candy test or undergo objectionable decomposition reactions when heated to a high temperature, as is necessary in certain industries. The nature of some of these impurities has been studied, as has also the distribution of organic colloidal material in the sugar crystal, and the nature of the salts present. As a possible means of improving the quality of direct-consumption sugars various proportions of different decolorizing carbons were used, and samples of the finished sugar were examined in the laboratory in comparison with refined sugars made by the customary process. An extensive examination revealed important effects of colloidal contaminants of sugar on foaming when sirups are prepared from the sugar. This was correlated with the surface-tension effect of the colloids in the sugar solution. Much information has been obtained which is valuable in indicating the most effective manner of using activated carbons and the proportions required.

CANE SUGAR

Investigations on cane-sugar production are being continued. Particular attention is being given to difficult filtration of raw sugar and to the difficulties of refining with bone char. Results to date indicate that slow filtration is due chiefly to mechanical action of particles in the filter medium which are of somewhat greater than colloidal dimensions. These particles consist to a great extent of material which is originally in the juice and is not removed by clarification, and also material which flocculates as a result of concentration of the juice to sirup, and also during the concentration of the sirup to massecuite. These different factors apparently vary in relative importance in different factories and in the same factory at different times. It has now been quite definitely established that these variations are due in part, at least, to variable factors as regards soil, fertilizer, and degree of maturity of the cane as they influence the clarification of the juice. The phenomenon in question is very similar to the variable occurrence of turbidity and separated flocculated material in cane sirup made on the farm in the Southern States. For instance, it is observed, in the case of cane sirup made from cane grown on soil which was heavily manured, that the sirup continued to deposit sediment for weeks after production. Even when the sirup was carefully strained and filtered after being drawn from the finishing pan, it became turbid and deposited flocculated material within a short time. On the other hand, sirup made from cane grown on light soils remains practically clear after being finished. Experiments are being made on selected lots of cane representing different cultural conditions, such as soil fertility, water supply, and drainage. A sugar company is cooperating by arranging factory runs of one to two days with lots of cane of selected types.

BEET SUGAR

Some study has been made of diffusion from plant cells with respect to proper operation of a diffusion battery, as in producing beet diffusion juice. Plans have been drawn for the construction of an experimental beet diffusion battery to be located in the laboratories in Washington. With this equipment the influence of various factors on diffusion of beet cossettes will be studied with the idea of devising a possible method to "hold back" certain colloidal impurities. Such means, if successful, would undoubtedly be more effective than clarifying the juice subsequent to diffusion.

The perfection of a procedure of automatic pH control of second carbonation of beet diffusion juice was completed during the year. This procedure will probably be installed by one of the beet-sugar companies for use during the next season. It is anticipated that attention will also be given to adaptation of this procedure to third saturation of beet diffusion juice.

MAPLE PRODUCTS

Suitably controlled maple sirup color standards are of great importance in the buying and selling of maple sirup. The standards in use in the industry during the last few years are based upon a caramel preparation prepared from granulated sugar as specified in Bulletin No. 134 of this bureau, Maple Sap Sirup; Its Manufacture, Composition, and Effect of Environment Thereon. We have been asked during recent years to prepare standards for distribution through the Extension Service. Investigation revealed that the colors obtained have varied by as much as one color grade (and in some cases more), according to the grade of refined granulated

sugar used. As a result of spectrophotometric study, color standards have been definitely fixed, thus making them reproducible and independent of the quality of refined sugar used. It was found that caramel prepared from different grades of refined sugar varied quantitatively but not qualitatively in color, thereby making it possible to use any caramel preparation made from refined cane sugar by diluting in the required proportions to give the various color standards.

State departments of agriculture, agricultural experiment stations, and extension services in the maple districts, particularly in Vermont, New York, New Hampshire, Maine, and Pennsylvania, cooperated with the bureau in the work of distributing master standards to the maple-sugar producers.

During the present year attention has been given to the diversification of maple products, particularly to the production of pure maple candies. For several years the production of maple candies in the maple districts has been increasing, but this development has been severely handicapped, owing to the poor keeping quality of the candy due to rapid drying out. During the present year formulæ were prepared whereby maple candies of a number of different types and of suitable keeping quality can be prepared by using a certain proportion of inverted maple sirup, made by inverting maple sirup with invertase. A mimeographed circular embodying this information was prepared and distributed through county agents.

HONEY

In cooperation with the bee culture laboratory and honey producers and exporters, an investigation was made of the diastase content of honeys treated and processed in varying manner. The diastase content was also studied in relation to a number of chemical characteristics.

This subject is of great importance in connection with the requirements of certain European countries to which honey is exported from the United States.

STARCH

A survey was practically completed on the utilization of cull sweetpotatoes, taking into consideration such factors as initial cost and operating cost of starch factories of varying size, distribution of sweetpotato production in the United States, variable transportation costs for raw material, and alternatives such as feeding cull potatoes to livestock.

Chemical and physical examination of sweetpotato starch produced at the Arlington farm plant was made and indicates that sweetpotato starch is on practically the same basis as white-potato starch with respect to general characteristics and methods of utilization. This conclusion, however, is by no means final, since much remains to be done in the study of dextrins and soluble starches produced from sweetpotato starch. A survey was made relative to the probable trend of use of domestic-potato starch in this country in competition with modified cornstarches and in competition with imported potato starch. Cooperation was established with a number of manufacturers of dextrins and modified starches for the purpose of obtaining suitable industrial tests. In cooperation with the first sweetpotato starch factory to be established in the United States much pertinent information was gained regarding the possible utilization of sweetpotato culls. A bureau representative was present during most of the period of operation and assisted the operating company by installing a system of chemical control and with suggestions as to procedure of operation.

MISCELLANEOUS INVESTIGATIONS

It is anticipated that some of the results of the colloid investigations relating to sorgo sirup, which were suspended this year because of reduced personnel, may be utilized in improving the clarification of sorgo juices, producing sirup of improved and more uniform quality. It is planned to continue this work actively during the next fiscal year. Although no work has been done during the present fiscal year on corn sirup and corn sugar, some of the results of the colloid investigation which is being conducted in connection with the clarification of cane juice can in all probability be applied to this subject to furnish clues to be used in improving the clarification of starch conversion liquors.

DUST EXPLOSION INVESTIGATIONS

Marked progress has been made in the reduction of the losses of life and property resulting from dust explosions in grain-handling operations.

Only 2 lives were lost, 29 persons injured, and property damaged to the extent of $888,000 in the 30 industrial-plant dust explosions investigated by our engineers since July 1, 1928. Studies of the causes of dust explosions in different types of industrial plants and methods for their control and prevention were largely responsible for the continued reduction in these losses during this year. Our work indicates very definitely that practically all types of combustible dusts are explosive when mixed in proper proportions with air and that nearly 30,000 industrial plants in the United States are liable to this risk. More than a million and a quarter people are employed in these plants, which manufacture products having an annual value of $10,000,000,000. As the only Government agency engaged in work for the prevention of industrial-plant dust explosions, the Bureau of Chemistry and Soils has received increasing calls for help as the leader in this undertaking in the United States.

INERT GAS

A great increase in the use of inert gas for fire and explosion protection has followed the publication of Technical Bulletin No. 74, entitled "The Value of Inert Gas as a Preventive of Dust Explosions in Grinding Equipment," which describes the investigations made at Arlington farm that clearly demonstrated the value of inert gas for such purposes.

In addition to the previously reported inert-gas installations made at two hard-rubber grinding plants, a cork grinding mill, a Pyrethrum-flower grinding plant, and a number of sulphur grinding mills have adopted this method of preventing explosions and a feed-grinding plant, in the Middle West, is now installing one of the largest inert-gas systems in the country. The use of inert gas to provide protection in one of the large starch plants is being considered, and experiments are under way to develop methods of properly cleaning and conditioning the gas for such use. Fire extinguishers filled with inert gas under pressure, instead of chemicals, are now being produced and are finding a ready market.

Methods of cleaning and conditioning flue gas to render it satisfactory for use as a preventive of dust explosion and fires are now being developed at Arlington farm. Two types of washers employing wooden grids, limestone, and water sprays have already been tested. Experiments with silica gel and aluminum gel to develop a method of removing moisture and objectionable fumes are also being made. Preliminary plans have been made to carry on experimental work to determine the value of inert gas for fire protection in cotton gins. The introduction of electrical power has eliminated the possibility of using steam, which was formerly employed to extinguish fires in the lint flues. A reduction in insurance rate for an installation where steam was used for this purpose has been granted. It is hoped that inert gas can be used where steam is no longer available and a similar or larger reduction in insurance obtained. Data on fire losses in the various States have been obtained and conference held with manufacturers of inert-gas fire-protection equipment. Conferences with cotton ginners and insurance company representatives have been planned.

LABORATORY RESEARCH

The work of the dust-explosion laboratory can be divided into two main divisions, research and service testing. Considerable attention was devoted to the development of apparatus for the determination of the relative degree of explosibility of various dusts.

The chief difficulty encountered in the development of dust-explosion testing apparatus has been the inability to obtain a uniform dust cloud in the bomb of the apparatus. A new type of dust-explosion apparatus has been designed which, it is believed, will overcome this difficulty to a great extent. Considerable time has been spent in making the design as simple and foolproof as possible.

Work is being done, using the new laboratory apparatus, to obtain fundamental data relating to dust explosions. These data will include information on such subjects as the following: The amount of dust actually burned; the amount of oxygen consumed with various concentrations of dust; time-pressure curves which show, in addition to the maximum pressure developed, the time required to reach maximum pressure with different dust concentrations; and possibly the rate of flame propagation in the bomb. To the best of our knowledge there is very little information in the literature covering any of the numerous relationships which may be deducted from such data. This work is being done with aluminum dust, because the product of combustion is a solid oxide. The partial-vacuum reading obtained after burn-

ing the aluminum is used to determine the amount of dust burned and the amount of oxygen consumed.

A number of tests were made to determine the oxygen dilution necessary to prevent explosion or propagation of flame in a dust cloud.

Tests to determine the lower explosive limit of ethylene oxide in an atmosphere containing ethylene oxide, air, and 10 per cent carbon dioxide were made. In preliminary tests it was found that the lower explosive limit of ethylene oxide in air is 3 per cent, which checks with the value obtained by another investigator; and the ignition of air-ethylene oxide mixtures where the ethylene oxide content is 3.2 per cent, or just 0.2 per cent above its lower explosive limit, produces very high pressure. Final tests showed that the use of 10 per cent carbon dioxide does not lessen the explosion hazard of ethylene oxide air mixtures, nor does it raise the lower explosive limit of ethylene oxide an appreciable amount. Care should be exercised in using ethylene oxide as a fumigant, even though the thoroughly mixed ethylene oxide-air mixture is nonexplosive, for explosive mixtures will exist in some parts of the room for certain periods until the gases are uniformily mixed.

INDUSTRIAL-PLANT STUDIES

Whenever any unusual operating conditions or dust-explosion hazards have come to the attention of the bureau an effort has been made to investigate and suggest to the management, or develop, methods of overcoming the hazards. A visit was made during the past year to a grain elevator in Baltimore where an oil switch had exploded. Recommendations were made and adopted by the company. A visit to a wood flour plant where several dust ignitions had occurred resulted in the adoption of a fine water spray within the grinders and the frequent wetting down of the room in order to provide relief against the explosion hazard. Visits have been made to mills and grain elevators to observe new grain-handling equipment and dust-collecting apparatus in operation. A study was made of possible dust-explosion hazards in a large spice-grinding mill, and venting equipment was recommended at several points. Visits were made and assistance given to a number of other industrial plants during the year.

Addresses before conventions or meetings of trade associations are frequently used to announce or call attention to methods of dust-explosion prevention, in addition to departmental publications and contributions to technical or trade journals.

DUST-EXPLOSION HAZARDS COMMITTEE

The bureau maintains close cooperation in dust-explosion-prevention work with the industries, insurance organizations, underwriting agencies, State commissions, and safety organizations. This makes possible very prompt application of the control and preventive methods developed by the bureau engineers. One of the most valuable contacts is that with the dust-explosion hazards committee of the National Fire Protection Association.

This committee under the leadership of the Chemical Engineering Division of the bureau is preparing safety regulations for the industries in which dust explosions have occurred. These regulations embody the results of the bureau's experimental work and become the basis of standards for State commissions, industrial companies, insurance associations, safety organizations, and other similar bodies. The committee has recently prepared regulations for dust-explosion control and prevention in the following lines of industry: Flour and feed mills; sugar and cocoa pulverizing systems; terminal grain elevators; pulverized-fuel installations; and starch factories. These regulations have been approved by the National Fire Protection Association and also adopted by the National Board of Fire Underwriters. They have been published by the United States Department of Labor as Bulletin No. 433, entitled "Safety Codes for the Prevention of Dust Explosions," in order to make them available for State labor departments, industrial boards, and similar State commissions intrusted with the protection of employees in manufacturing establishments.

FARM FIRES

To decrease the huge loss from fires in rural America, which it is estimated take a toll of 3,500 lives and destroy $150,000,000 of property annually, the bureau has continued its study of the causes of fires and its investigation of methods of preventing farm fires. Research is progressing along engineering, chemical, bacteriological, and educational lines. Some results and findings of this work have been published during the year in

Farmers' Bulletin 1590, Fire-Protective Construction on the Farm and in Circular 76, Fires in Cotton Gins and How to Prevent Them. As the titles imply, these publications, which have been widely distributed, contain information on simple methods of constructing farm buildings whereby fire protection can be most readily and cheaply effected, outline the principal causes of farm fires and methods for their prevention, and deal with methods of preventing fires in cotton gins. The principal causes of farm fires which are emphasized are the following: Spontaneous ignition of hay, grain, feeds, and other agricultural products; lightning; defective chimneys and heating apparatus; sparks on combustible roofs; careless use of matches in smoking; careless handling and storage of gasoline and kerosene; and faulty wiring and improper use of electrical appliances.

SPONTANEOUS IGNITION OF HAY

The spontaneous heating of wet hay stored in barns following the Vermont flood of 1927 was a striking demonstration of the importance of this factor in farm fires. The investigation of the causes and the chemical processes underlying the spontaneous ignition of hay and other agricultural products is intended to include as well the investigation of the heating of these products which does not of necessity lead to actual fires, but which nevertheless causes immense loss from deterioration and spoilage. Laboratory work on several phases of the subject of spontaneous heating has been carried on during the present year. As a requisite for the work on hay, an accurate method for the determination of its moisture content has been selected after careful experimental comparison of several methods.

Various theories which have been advanced to account for the self-ignition of hay are being investigated in the laboratory. One theory is that self-ignition of hay is due to "pyrophoric hay carbon" which resulted from an experiment by Ranke in which hay was heated to 250° to 300° C., carbonized, and shaken and poured out on a porous plate, following which it was observed to glow after a few minutes and finally to calcine. The theory advanced by Laupper contends that the ignition is due, not to pyrophoric carbon but to the pyrophoric iron present in it. Accordingly, "hay carbon" has been prepared and tested for pyrophoric property. That this exists has been confirmed, but whether it is due to the carbon or to other matter associated with the carbon, or to pyrophoric iron, remains to be determined. Further experiments are in progress looking to the solution of this problem.

Experiments have been started to determine the action and products, both bacteriological and chemical, of the heating of hay at comparatively low temperatures under anaerobic conditions. Tests will be made especially for unsaturated, unstable, and readily oxidized products.

LARGE-SCALE EXPERIMENTAL WORK

Large-scale field experiments on the spontaneous ignition of hay are being conducted in a suitable structure 24 feet wide, 26 feet long, and 22 feet high to the ridge, erected on the Animal Husbandry Experiment Farm at Beltsville, Md. The spontaneous heating and ignition of hay is being studied here from the bacteriological, chemical, and engineering angles under conditions believed to be ideal and simulating as nearly as possible those on farms. The barn has a capacity of approximately 35 tons of hay. The initial research is being made on only 14 tons. An enlarged laboratory experiment is also being carried on in conjunction with the large-scale test, utilizing three-quarters of a ton of hay in a tightly constructed box. In both cases extensive temperature readings are being obtained by means of a large number of thermocouples, and samples of hay and gases are being collected from the hay under observation for analysis and examination. The results of the first experiments are not yet available. This work has been planned to cover a period of at least three years, and subsequently experiments will be conducted along expanded and modified lines suggested by the initial research.

A revolving, tubular hay sampler has been designed and constructed for use in these large-scale field experiments on the spontaneous ignition of hay.

Studies of the ignition and heating of hay and other agricultural products have included contacts with agricultural colleges engaged in similar investigations, and special investigations of serious farm fires where spontaneous combustion was regarded as the cause.

Studies are also being conducted on modern haying methods and machinery as affecting spontaneous ignition of hay.

FARM FIRE PROTECTION COMMITTEE

Leadership of the farm fire protection committee of the National Fire Protection Association has devolved largely upon the Bureau of Chemistry and Soils in view of the fact that officials of this bureau have been appointed as chairman and secretary of the committee which is composed of 15 representatives of national organizations and 4 members from the United States Department of Agriculture. Two meetings were held during the year, one October 1, 1928, in Chicago, the other April 2, 1929, also in Chicago. Reports on rural fire departments and fire-protective construction on the farm contained, respectively, information on standards for rural fire-fighting apparatus and information on fire-department organization, personnel, duties, drills, etc.; instructions in bulletin form (Farmer's Bulletin 1590) as to fire-protective construction of homes, barns, and other buildings on the farm.

Representatives of this bureau are also taking an active part in the work of the agricultural committee of the National Fire Waste Council and of the farm fire-prevention and control committee of the American Society of Agricultural Engineers.

Six radio talks were delivered each to a potential audience of 400,000 listeners. Twelve articles were also published in the press and trade journals. A 7-panel, animated farm-fire booth was extensively shown at fairs, conventions, and meetings. Three addresses were made before gatherings of national prominence.

EXHIBITS AND PUBLIC INFORMATION

Special booth exhibits were constructed to show the work on farm fires, naval stores, soil erosion, and leather and tanning materials, while other exhibits showed activities of the bureau in connection with food colors, making cellulose from peanut shells, gluconic acid and salts, dye intermediates, citrus products, rotenone as derived from Derris root, "Neo," a new nicotine spray, ethyl formin, methal chloroacetate, soil analysis, soil fertility, concentrated fertilizers, gas laws at high pressures, work of the division of physics, a stirring machine for phosphoric acid, and a shaking machine for phosphoric-acid determinations.

The bureau participated in exhibitions at the Association of Official Agricultural Chemists convention in Washington, the International Live Stock Show, and the American Farm Bureau Federation Meeting, at Chicago, the Inaugural exhibit in Washington, the Pacific Southwest Exposition, in Long Beach, Calif., the Chemical Industries Exposition, New York City, and the National Fire Protection Association meeting in Memphis, Tenn.

COLOR AND FARM WASTE

The most successful contribution of the Color and Farm Waste Division to the chemical industry was the invention of the process for the production of phthalic anhydride by the catalytic oxidation of naphthalene. This process has been of inestimable value, both to the vat dye and to the lacquer industries. The 1927 dye census tells us that the phthalic anhydride output by American factories in 1927 was the highest on record, 4,549,825 pounds. The unit sales value of this product was 17 cents a pound as against an invoice value of 24 cents a pound in 1914 when our entire consumption was imported from Germany. With the working out of this process, the bureau established itself as one of the leaders in the field of catalytic oxidations and subsequently worked on the production of anthraquinone from anthracene in a similar manner. This process is also of great importance, although priority in the patent field has been granted to a German inventor.

DYE INTERMEDIATES

A logical outgrowth of the bureau's work on phthalic anhydride is the investigation of the Friedel-Craft synthesis. The outstanding industrial example of the Friedel-Craft synthesis is the process for anthraquinone, by which this most important dye intermediate is manufactured from benzene and phthalic anhydride, instead of from anthracene. Similar processes may be developed, using other components in the place of benzene, by which the field of dye intermediates, with particular emphasis on vat dye intermediates, may be greatly enriched. For these reasons this particular project will be of great value to the dye industry.

During the past year our work on the synthesis of 2-aminoanthraquinone

from phthalic anhydride and chlorobenzene has been reported. It appears that several large dye industries are interested in this process, as it offers a more economic means of preparation than the older method of preparing anthraquinone, sulphonating, and separating the monosulphonic acid and then aminating.

Exhaustive experiments have been carried out on the preparation of naphthoyl-benzoic acid and naphthanthraquinone. A great part of the value of this process lies in the fact that naphthalene, as a raw material for dyes, is plentiful and cheap, whereas benzene and its homologs are likely to become more expensive with the development of their use in motor fuels.

Recently diphenyl has come on the market in large quantities and in a fairly pure state. It appears to offer an attractive raw material to build up a new series of vat dye intermediates and presents a field which is for all practical purposes a new one.

BIOLOGICAL APPLICATION OF DYES

The question of the biological application of dyes is inextricably bound up with the problem of national health. Dyes are used internally and externally in the treatment of diseases, any they are used very widely in the diagnosis of pathological conditions. These applications are increasing all the time and it seems reasonable to predict that they will continue to grow in the future as rapidly as they have in the past. As an example, this bureau was recently consulted by representatives of a university in connection with the development of a differential stain for the cancer cell. Stains are now used in the diagnosis of cancer, but a highly developed technic and knowledge of the subject is required. If a stain could be developed which would stain not only the recognized but the incipient cancer growth in a way which would make it stand out from the healthier cells in its neighborhood, a distinct advance could be made in the treatment of this disease. The bureau has been asked to furnish, by synthesis or otherwise, the dyes which may be indicated as experiments progress.

MISCELLANEOUS INVESTIGATIONS

The routine examination of stains has required a large amount of work during the past year owing to extensive collaboration with Army authorities as well as with the stain commission. Fully 35 per cent of the time of two workers has been devoted to this routine, and about 200 samples of stains have been reported on either verbally or in writing. This work has included the chemical part of the standardization of stains for the commission on standardization of biological stains, also extensive work in connection with the setting of stain standards for the Government purchase of these materials.

In the syntheses of biological stains and dyes of antiseptic or therapeutic value, the main problem to which this division has devoted itself during the past year has been a study of the different fuchsins and their homologs. It has been noted in the past that dyes of this class produced by different manufacturers under the same name have differed widely in their staining properties. Investigation of this phenomenon has shown us that while these dyes are supposed to be the same material they do in fact differ very widely. This division has synthesized a number of basic and acid fuchsins and is now studying them with a view to correlating their chemical and spectrophotometric characteristics. Later on these materials will be studied elsewhere from a staining standpoint.

In testing the fungicidal properties of dyes the inhibitory effect of about 25 representative dyes upon *Penicillium luteum-purpurogenum* has been investigated with interesting results.

FARM-WASTE INVESTIGATIONS

Investigations as to the utilization of several kinds of farm waste have been conducted during the year. Lignin is one of the three great components of agricultural wastes. Thirty per cent of the dry material of all vegetation is lignin, and the annual production of this material has been estimated as being 40,000,000 tons. Most of this is at the present time wasted. A great proportion is lost in the waste liquor from the paper mills, and more is discarded on the farm in cornstalks, corncobs, straw, etc.

Lignin has been the subject of investigation for many years, and its exact composition is one of the great chemical enigmas. The industrial usefulness of a chemical compound in these days depends on a knowledge of its constitution, for with the development of modern methods of research, the day of empirical chemical manu-

facture is almost past. The project on lignin was originally formulated for the purpose of finding out the chemical structure of this material. With this in view the work on destructive distillation of lignin has been carried on by this bureau. When lignin was distilled destructively under reduced pressure, four products resulted. On the basis of lignin used, the yields of these products were as follows: Oily distillate, 30.5 per cent; aqueous distillate, 12 per cent; carbon residue, 43.5 per cent; and gas, 14 per cent.

The aqueous distillate contained 0.6 per cent of methyl alcohol, 1 per cent of acetone, and 0.4 per cent of acetic acid. Over 80 per cent of the oil was of phenolic character and eugenol and guaiacol were identified in this. This high yield of aromatic compounds obtained from lignin is believed to be significant from the standpoint of the structure of lignin, as it gives weight to the hypothesis that lignin is cyclic in structure.

The potential value of this phase of the lignin work is very great. Eugenol is the essential constituent of oil of cloves. In the latter form it is quite largely used pharmacologically, and the basic constituent itself is used in the manufacture of vanillin. Guaiacol is also used in pharmacological work. If we take into consideration the amount of lignin that goes to waste in the paper industry and elsewhere, it will be seen that the development of this process offers a potential cheap source of eugenol and guaiacol.

Study of the rôle of lignin in animal nutrition by experiments on dogs and cows and by investigations carried out in vitro with the juices from a cow's stomach and intestines, proves that the animal body is capable of breaking down lignin. In its passage through the system lignin suffers a loss of 30 per cent of its original methoxyl content. This breaking down takes place in the stomach of the animal and is apparently brought about by an enzyme.

In the study of the humification of lignin, analyses indicate that the effect of the action of ordinary soil organisms on cornstalks, oat hulls, corncobs, and wheat straw is to cause considerable decomposition of lignin along with the greater decomposition of the pentosan and cellulose. It has generally been assumed that lignin is not attacked by soil organisms, or at least only to a limited extent. The results obtained will throw new light on the general problem of the organic matter in the soil. There is some question as to whether or not the lignin from different vegetable sources is of the same composition. A study was made of lignin from oat hulls, by the same methods as those previously applied to lignin from corncobs, and the results obtained are quite similar to those obtained on the latter product.

CATALYTIC OXIDATIONS

During investigation of the catalytic vapor-phase oxidation of p-cymene, tests have been made of a number of catalyst carriers, such as unglazed porcelain, asbestos, pumice, and silica gel. Several different types of apparatus have been built and tried out for the purpose of obtaining optimum rate of flow, time of contact, and condensing conditions. Most of the studies have been made using vanadium pentoxide as the catalyst, but a number of mixtures have also been tried. Both air and pure oxygen have been tried as oxidizing mediums. The reaction between p-cymene and oxygen takes place quite readily at a temperature of about 400° C. A number of products are formed. Those so far identified are as follows: Paratoluic acid, tere-phthalic acid, formaldehyde, formic acid, water, and carbon dioxide. Considerable p-cymene is recovered unoxidized.

Although p-cymene is produced in this country at the rate of about 10,000,000 pounds annually, little use for it has been found, despite the fact that a number of investigations on the subject have been carried on in this bureau and elsewhere. Some of the outlets suggested for p-cymene will be of value when the industry has been persuaded to recover and purify it in such amounts as will bring about the lowering of the price. If the catalytic oxidation is successful in producing organic materials of value to industry, an important step will have been taken along this line.

INDUSTRIAL FERMENTATIONS

A marked feature in the progress of chemical industry in this country and elsewhere during the last 10 years has been the employment of microorganisms to perform large-scale chemical transformations. In many cases these organisms will carry through complete reactions in a way that is cheaper and simpler than the ordinary chemical process, and it has been felt that the application of this idea offered special promise in the utilization of agricultural products and wastes.

The study of industrial fermentations was begun in 1926. Following a preliminary survey of the action of nearly 200 molds on solutions of glucose, one organism was selected because of its ability to produce large quantities of gluconic acid, and intensive study has been given to this problem, both on a laboratory and semiplant scale. The past year has for the most part been devoted to a study of processes for mold fermentations, conducted on a semiplant scale, with particular reference to the production of gluconic acid by the action of fungi on corn sugar. Since no statements have been found in the literature regarding the commercial development of laboratory processes for the production of organic acid by mold fermentations most of this work has been of a pioneering nature.

During the past year 65 pounds of calcium gluconate has been sold at $2 per pound to various research centers interested in its physical, chemical, and physiological properties. Preliminary reports from some of these investigations indicate that calcium gluconate may find a wide and valuable use as a remedial agent in pathological conditions induced by calcium deficiency.

Preliminary experiments have indicated that high-production hens laying thin-shelled eggs may be helped in the production of thick-shelled eggs by the addition of small quantities of calcium gluconate to their feed. It is hoped that these investigations will be extended to high-production dairy cows which often suffer a severe strain on their calcium reserve due to the large amount of milk produced. While calcium salts of other organic acids apparently have little effect in maintaining a high calcium level in these cattle, calcium gluconate might prove highly beneficial. It is impossible at the present time to estimate in dollars the value of the industrial fermentation investigation. One firm has, however, taken up the process and is engaged in working it out on a small-plant scale. Another concern is giving it serious consideration and has requested and received a culture of our mold. Furthermore, the process and the possibilities of utilization of gluconic acid and its salts have been the subject of numerous written inquiries and personal interviews from those interested.

In taking up the study of the utilization of molds, the bureau has established itself in a field which is receiving much attention both here and abroad and which will probably in the future prove increasingly important to the chemical industry.

CROP CHEMISTRY LABORATORY

The crop chemistry laboratory has continued scientific study of the factors which affect the quality of crops grown in the United States with the purpose of obtaining information on the interrelation of these factors, so as to make possible such modification of existing agricultural practice as will improve the quality of our food supply.

In the field study of increasing the protein content of wheat at the Arlington Experiment Farm, sodium nitrate has been the fertilizer chiefly used heretofore, but as other nitrogen compounds such as ammonium sulphate, calcium nitrate, urea, etc., are now coming into wide use, it seemed important to compare the results, which might be obtained with these, with those obtained previously. A series of plots for this purpose has been laid out and the fertilizers applied.

Work on increasing the phosphorus content of wheat has not yet reached the stage where plots can be laid out, but during the year further experiments were made on the absorption of phosphorus by wheat seedlings in culture solutions, and some analyses were made of crops grown during previous years as to phosphorus content.

In view of the interest shown in manganese as a constituent of foods, work on this element was continued. Improvements were made in the official method for determining manganese, and analyses made of a large number of samples of cereals and their products. Wheat seedlings were also grown in culture solutions containing manganese in various forms, and the principles of absorption of this element were worked out.

The study of the absorption of food constituents by young plants, which has been under way for several years, was continued, further observations being made on the effect of varying the conditions on the absorption of potassium and phosphorus by wheat seedlings.

FOOD-RESEARCH INVESTIGATIONS

FRUIT AND VEGETABLE CHEMISTRY

Important work has been accomplished during the past year on the effect of ethylene on the composition and physical condition of Bartlett pears to be used for canning and drying. The results obtained with

canning pears were so promising as to warrant an extension of this work during the coming season. An advantage to the canning industry in the application of ethylene to pears, and possibly other products, is to reduce the necessary storage period for the ripening and also to reduce considerably the labor cost which is incurred in the frequent sorting and handling of pears under present conditions. If further tests indicate the practicability of this method of handling pears it appears probable that the method will be rather generally adopted, especially by the larger commercial canners of pears. This method also promises beneficial results in connection with the canning of apricots and peaches, upon which work will be undertaken during the 1929 packing season.

Investigations of methods of sulphuring apricots, peaches, and pears have been actively continued during the present year. Two field laboratories are located at central points so that both the apricot and peach sulphuring could be studied in the producing sections of California.

In the fruit and vegetable by-products studies at Los Angeles, the laboratory work on the composition of California citrus oils was completed. In the same by-product field, a beginning was made of the study of the manufacture of pectin from grapefruit waste and also on the manufacture, utilization, and composition of grapefruit oil. The inheritance of composition through vegetative propagation has been studied in the case of Eureka and Lisbon lemons. Investigation has also been made on the effect of freezing on citrus fruits.

FOOD SPOILAGE AND DETERIORATION

The commercial production of mayonnaise has reached the point where it is regarded as one of our major food-manufacturing industries. In the marketing of this product certain difficulties are encountered, such as the actual bacterial spoilage of the product, the development of rancidity, and the breaking down of the emulsion. These conditions render the product unfit for sales distribution.

Before undertaking a study of the spoilage of mayonnaise, it was necessary to develop a standard formula and standard methods for determining the quality. The standard methods adopted were as follows: A physical method for the determination of consistency, a physical method for the measurement of color, a chemical method for the determination of acidity, and a microscopic method for determining the character of the emulsion. The flavor was determined organoleptically.

In the substitution of acids for vinegar in the mayonnaise samples, pure acetic acid was found unsuitable because of a marked acid odor and an absence of sufficient preservative properties; lemon juice produced a product of good quality and of good stability, though no lemon flavor was noticeable. Lactic acid made a product of high quality. After three months' storage these samples were better in consistency and character of emulsion and showed less development of rancidity than did the samples made up with vinegar or other acids.

During the present year a new and peculiar type of molding of shell eggs in cold storage has been studied. The mold organisms were isolated and identified as species of Cladisporium and Penicillium. Preliminary indications point to the possibility of an initial oil treatment of the eggs as a possible method of combating this type of storage spoilage.

During the past year one of the large can-making companies announced the development of a new process for canning vegetables whereby the use of brine or water was eliminated. This process required the closure of the cans under a high vacuum before the processing operation was carried out. A number of tests have been made on a modification of this method whereby the high vacuum in the closed can is obtained by exhausting with steam. The flavors of vegetables canned by this method are markedly improved over those of the ordinary canned products—in fact, are closely comparable with the flavors of the freshly cooked materials. A number of different vegetables can be effectively canned by this method.

MILLING AND BAKING

In the investigation on cake making different grades of flour made from different classes of wheat were used, both alone and with the addition of 20 to 25 per cent of other substances—for instance, white-corn flour, gelatinized-corn flour, various starches, soybean flour, and potato flour. Very successful results were obtained, especially with the use of corn flour and

cornstarch. A mixture of wheat and soybean flours likewise made cakes of very good quality, which on further study may prove of special interest to the trade. The importance of cake investigation is evident when it is realized that over 50,000,000 barrels of flour are used in making cake, the value of which product is over $1,000,000,000 yearly.

The use of flour made from germinated wheat, other cereals, legumes, etc., is giving interesting results. Most of the evidence seems to point to the fact that the use of a small amount of flour made from slightly germinated grain or seed mixed with ordinary flour improves the baking value of that flour. The volume of the loaf is larger, and the texture, and in some cases even the color, is improved.

PHYTOCHEMICAL INVESTIGATIONS

From the investigations of this division it appears that susceptibility to surface scald in apples held in storage is correlated with the percentage of "oily fraction" in the total ether extract of the waxlike surface coating. The higher the percentage of this fraction the less permeable to gases is the natural coating of the apple. When this percentage is high a condition of abnormal respiration is brought about through the accumulation of carbon dioxide within the fruit, and this accumulation is directly responsible for the formation of acetaldehyde. This volatile product is considered the direct cause of skin browning, which is characteristic of scald. Differences between the respiratory activity of the sunny and green sides of the same fruit as well as between that of a fully colored and of an immature apple probably account for the fact that scald is more prevalent on the less-colored portions and on an immature fruit. Ventilation is believed to retard the accumulation of carbon dioxide within the tissues, which might otherwise occur as a result of the physical nature of the waxy coating. The use of oil wrappers for the control of scald has no effect in preventing a condition of abnormal respiration, but it may be that the mineral oil in the oil wrappers absorbs the toxic acetaldehyde formed under these conditions. During the year an exhaustive study has been made of ursolic acid, which is one of the three major constituents of so-called apple wax. As a result of this work it is possible to state more definitely than heretofore, the chemical identity of this substance.

CHEMISTRY OF PLANT PRODUCTS

The results of previous investigators were confirmed as to the presence of formic, acetic, aconitic, malic, and lactic acids in sugarcane molasses. In addition to these, citric acid, not previously reported as a constituent of cane molasses, was identified.

Cane molasses "slop" was found to contain formic, acetic, succinic, tricarballylic, and lactic acids in considerable amounts with a very small amount of aconitic acid and a possible trace of citric acid.

Knowledge of the unstable acids resulting from the action of lime on glucose has been furthered. Winter's so-called glucic acid has been prepared and its properties studied. There is very strong evidence that it is the half aldehyde of malonic acid, described by Pinner as acrolactic acid. The great rise in temperature when its calcium salt is exposed to air simulates the phenomenon of "spontaneous combustion," and it becomes a pertinent question whether such an unsaturated compound as this may not play a part in the "heating" of agricultural products, especially of hay.

INDUSTRIAL FARM PRODUCTS

HIDES AND SKINS

As a part of the department's broad program of research on the conservation of hides and skins, field work with butchers, dealers, and tanners has been actively continued on the elimination of poor practices in skinning and curing, which cause a waste of essential raw materials estimated to be at least $20,000,000 a year. Two hide specialists, one in Pennsylvania and the other in Virginia, North Carolina, and Tennessee, have been continuously at work among producers and handlers of hides and skins, pointing out to them poor practices and correcting such practices whenever possible by demonstrations and advice. Many glaring examples of poor technic are being found, and many of the producers fail to understand just what such poor practices on hides and skins mean in terms of the quantity, quality, and appearance of the leather made from them. Educational work is being done to bring about a fuller realization of the consequences of such defects.

The best results from this work on hides and skins can only be realized

after standard grades have been set up and accepted as an essential part of trade practice. To establish standard classification and grading and to improve marketing conditions this division has cooperated closely with the Bureau of Agricultural Economics in assisting it to prepare tentative schedules for grades and classes of hides and skins and in other phases of its work. In this connection considerable time has been spent in the field interviewing hide dealers on the subjects of selective trading and improvement in the grades of hides and skins.

SALT STAINS

Bacteriological researches have been started with particular reference to the origin and prevention of salt stains on hides and skins, a serious damage of long-recognized standing. The origin of salt stains is still a debatable matter, though they are believed to be the result, in part or entirely, of bacteriological action. Consequently bacterial studies are now being centered on salted hides and skins and on used and unused salts to isolate as many cultures as possible of halophilic or salt-tolerant organisms, and particularly those that are chromogenic or color producers. Several such organisms have been isolated, and the work is being continued.

TANNING MATERIALS

Depletion of our forests by man and diseases, including particularly the blight of the American chestnut tree, is steadily bringing about a greater and greater shortage of domestic tanning materials. Looking to the future when the supply of vegetable tanning materials may become an acute matter unless provision is made in the meantime, special efforts are being put forth to secure or develop new sources of tannin. In cooperation with the Office of Forest Pathology, Bureau of Plant Industry, woods and barks from foreign sources are being examined for their tannin content. Of those so far examined, only the *Castanea crenata* has shown any considerable tannin content. The wood of this tree has, on the moisture-free basis, from 12 to 15 per cent tannin, and the bark 14.6 per cent tannin.

Also in cooperation with the Office of Forest Pathology data are being obtained on the vertical distribution of tannin in Chinese chestnut trees and roots grown at the experiment orchards at Bell, Md. These data will afford a means of comparing the tannin content of Chinese chestnut trees grown indigenously and in this country and can also be used in arriving at the tannin yield of an entire tree from a tannin analysis of only one part, such as the top branches.

FERROCHROME TANNING

Public service patent applications have been prepared and filed in the United States Patent Office on ferrochrome as a tanning material, following laboratory experiments, which have indicated some interesting possibilities of a joint chrome-iron tannage by the use of certain ferrochrome solutions. Large-scale tanning experiments have been arranged but not yet carried out.

LEATHER

Realizing the ultimate costliness and extravagances of the rapid deterioration of leather bindings, resulting primarily from the use of leathers of improper tannage, the bureau has collaborated with the United States Government Printing Office in examining chemically and physically for that office all of the leathers used in its public binding work. During the past year 40 leathers of both regular and special tannages have been examined, most of which were found not to be satisfactory for long-service bindings.

As a part of investigational work in securing composition data on available leathers and in drawing specifications for leathers, the bureau has collaborated with the Government Printing Office in a chemical and physical study of a special collection of English bookbinding leathers. The results of this study, with a discussion of their significance, have been published for the information of tanners and users of bookbinding leathers. All of the leathers of this special collection that were claimed to be acid free and pyrogallol tanned were found to be so and thus to comply with two of the essential requirements for durable bookbinding leather.

DETERIORATION OF BOOKBINDING AND OTHER LEATHERS

Recently the Library of Congress brought to the attention of the bureau the fact that many thousands of its leather bookbindings were in an advanced stage of rotting. On the basis of data acquired over many years of

experimentation and research on the deterioration of leather, the bureau prepared and recommended several leather dressings, which if applied periodically would help to arrest further decay of old leather bindings and if applied before material decay has set in, would add years to the life of the bindings and thus save the Library of Congress many thousands of dollars in rebinding. These dressings are now being supplied to the library and systematically applied to its leather bindings.

VEGETABLE AND CHROME-RETANNED SOLE LEATHERS

Because of an ever-increasing shortage of vegetable tanning materials and the consequent possibility of future developments hinging upon chrome tannages, experiments are being made to obtain fundamental data on the wearing quality and other properties of chrome-retanned sole leather as compared with the well-known, long-established, vegetable-tanned sole leather. The work is being done on leathers made from the same hides, which gives a strictly comparable basis that is so essential for work of this general nature and yet is so seldom obtained. A particularly interesting point brought out by the data is that the tensile strength of the chrome-retanned leather is less than that of the vegetable-tanned leather. It is also thinner than the latter unless heavily retanned. Actual wearing tests on these two leathers have been completed, but the detailed data have not yet been assembled and analyzed. The results so far show that on an average the chrome-retanned sole leather, if heavily retanned, wears longer than the vegetable-tanned leather. The chrome-retanned leather did not prove satisfactory, however, as regards water resistance and also in some cases did not afford sufficient protection to the bottom of the foot against uneven surfaces because of its soft nature.

THE EFFECT OF OILS AND GREASES ON LEATHER

Because of the known wide difference in the efficacy of various oils and greases as leather dressings, an elaborate experiment on the preservative effect of 20 oils and greases on leather is under way. Complete chemical data on the oils and greases have been obtained for correlation, if possible, with their effect upon the leather after it has been aged by exposure both indoors and outdoors.

NAVAL STORES

The work on turpentine, rosin, pine oil, pine tar, pine pitch, rosin oil, rosin spirits, and other resinous farm and forest products derived from the pine tree and generally known collectively as naval stores, which are produced to the extent of about $60,000,000 worth annually in this country, has progressed very satisfactorily during the year. These farm and forest products are recognized as materials essential to the paint, varnish, paper-size, soap, printing-ink, polish, and other major industries of the country, and in addition supply the needs of foreign countries for these materials. The need for research work of a fundamental and also of a practical nature is more pressing than ever, despite the bureau's past efforts to help both the producers and users of these products. Every improvement which the research work of the bureau introduces in process work or production gives the users of naval stores a better material and one less difficult to work with.

BETTER SETTING FOR FIRE STILL

In the technological field work which the bureau has been conducting for a number of years, it has been the general observation that the working of the stills was inefficient in some particular: The gum was scorched and the rosin thereby degraded, the yield of turpentine was not as great as it should have been; fuel consumption was too high; the still ran irregularly and showed a tendency to go flat or boil over, or it took too long to work off a charge. Study of the problems presented revealed that in many, if not in most instances, the setting of the still was at fault. It could not be uniformly heated, there being portions of the still that were cold and other portions that were too hot. The still was found to be hotter immediately above the gum line, especially, than it should be. There was not the necessary protection against accidental fire and destruction of the still. The flues were too small, and, as a consequence, the draft was not adequate to insure prompt, rapid distillation, and the final results were low-grade rosin and slow and costly operation, interspersed with frequent fires which destroyed the still and all of the gum, rosin, and turpentine within reach.

Serious experimental study during the past two or three years has finally resulted in the introduction by the bureau of an improved setting for fire stills. This setting is found to give complete satisfaction in that it reduces the tendency to scorch the gum and lower the grade of rosin, reduces the fuel consumption, shortens the time of distillation, and simplifies the operation of the still.

Blue prints and instructions for the proper setting of the fire still were prepared for distribution to naval-stores operators. There have been many calls from producers and from those interested in distillation for these plans and specifications, and those producers who have rebuilt their stills in accordance with the bureau's plans and specifications have advised the bureau that they have profited directly thereby.

A representative of the bureau has personally supervised the setting of a number of fire stills according to these plans and instructions, in one instance supervising the construction and lay-out of the entire plant. Many reports have been received concerning the satisfactory results that have been obtained in the operations of the reset stills. Increased yields of turpentine and better grades of rosin have resulted.

FIELD TECHNICAL SERVICE

Service of a technical nature has been given operators through the office of the naval-stores technologist, located at Savannah, Ga. During the year more than 50 visits were made to plants producing naval stores. The services rendered at these times have been extremely varied. Advice and help were given on the layout of the plants and the type of equipment necessary for securing maximum efficiency; the problem of minimizing fire danger was handled; instructions were given in improving the methods of still operation and rosin straining; proper methods of handling crude gum were emphasized, and the reasons pointed out for muddy turpentine and smoky, stained, and dirty rosin. Special attention was given in all instances to the problem of producing higher-grade products.

These visits, the suggestions, and the help are given at the request of the individual naval-stores producers. The demand for help along these lines has been greater than the bureau has been able to meet with its present facilities. That the work is beneficial to a large degree and is appreciated by the turpentine and rosin farmers is convincingly shown by the letters of commendation and requests for help received both by the Savannah office and by the bureau in Washington. It is estimated that the value of this technical service which the bureau is rendering the producers of turpentine and rosin is worth at least half a million dollars a year to the industry.

CUPS AND APRONS

Galvanized-iron cups and aprons are largely used for collecting turpentine gum from the trees. Frequently operators continue to use them after they become rusty, not realizing to what extent their profits may be cut by degraded rosin caused by iron-stained gum. In order to demonstrate the harmful effect on the color or grade of rosin resulting from the use of rusted galvanized-iron cups for collecting crude gum and the comparative effect of different metals, 0.5 per cent of metallic resinate was mixed with uniform samples of light-colored rosin and the mixture fused under uniform conditions of time, temperature, and agitation, and then compared with the same rosin heated alone. It was found that heating with zinc or with aluminum resinate darkened the rosin only slightly more than if it were heated alone under the same conditions. Heating with 0.5 per cent of iron resinate darkened the rosin greatly—as much as three or four grades—while heating with copper resinate had the next greatest darkening effect on the rosin. Heating high-grade rosin with as little as 0.01 per cent of iron oxide was found to lower the grade of the rosin. This work, which so clearly showed the effect of iron resinate in decreasing the producer's profits, is being continued with a view to developing the best way of keeping iron rust out of the gum.

SPECIFIC-GRAVITY TABLES

Since under the methods of production there can be no foreign oils in spirits of turpentine, especially in gum spirits of turpentine, few tests as to the purity of spirits of turpentine are made on the primary markets. However, for the purpose of calculating the weight or gallonage of tank cars

or to determine whether or not the turpentine has oxidized in storage, it is customary to determine the specific gravity or the Baumé gravity of turpentine on the primary markets or at the time a tank car of turpentine is shipped from the still. This determination is customarily made at the prevailing temperature of the turpentine, and the weight per gallon or per tank car and the correct gravity are obtained by reference to proper tables.

At the suggestion of the Pine Institute of America (Inc.), work was done to determine whether hydrometers calibrated for use at 60° F. can be used with turpentine at temperatures much above or below 60°, and the results corrected with reasonable accuracy. From experiments with 16 authentic samples of turpentine, tables of gravities have been prepared showing how to obtain the true specific or Baumé values at 60° from readings made at other temperatures, ranging from 32° to 95° in 1-degree intervals.

These tables will facilitate calculation of volume from the weight or weight from volume of turpentine when sampled and tanked where no convenient means of regulating temperature are available. The results of this work with tables for correcting specific gravity and giving weights per gallon of turpentine of different specific gravities will be published at an early date.

STEAM STILL

During the year the bureau has kept in close touch with producers who have installed steam stills, including those built in accordance with the designs and specifications of the bureau and those in which departures were made by the builders of the stills. Careful study of the installations so far made show that stills not constructed in accordance with the bureaus' specifications have given considerable trouble and usually have to be reconstructed. Those which were built in strict accordance with the bureau's specifications have continued to prove satisfactory and economical, although several minor changes have been made which have resulted in easier and more uniform handling of the stills.

GUM CLEANING

Work on gum straining has continued with promising results. For the first time, so far as it is known, crude gum was strained entirely free from fine bark, sand, clay, chips, and other material usually present in the gum, without diluting it with a solvent, and the rosin produced was clear and brilliant. This work has reached the stage where it is felt that with proper facilities the necessary practical equipment can be constructed and operated with every promise of success. It is felt, however, that further work along this line must await the facilities furnished by a naval-stores experiment station before it can be completed in a satisfactory manner.

TURPENTINE STORAGE

In the work on improved methods for storing turpentine, several substances have been tested as to their value in preventing or retarding oxidation. It has been found that metallic copper, zinc, magnesia, and sodium all react with the terpene acids, forming flocculent precipitates, and are therefore not suitable for the purpose. Stannous chloride also reacts with the turpentine and can not be used. Sodium nitrate, calcium sulphate, and calcium chloride appear to be of little or no value. Hydraquinone, pyrogallol, pyrocatechin, and beta naphthol, while of value in retarding oxidation, caused darkening of the turpentine. The work is being continued with those substances which so far have indicated that they may be of value in retarding oxidation.

In the meantime, however, it appears that keeping containers, whether they be barrels, drums, or storage tanks, completely filled with the turpentine and free from separated water is the best insurance against oxidation and thickening of turpentine in storage.

GLUING TURPENTINE BARRELS

While a large percentage of the turpentine made is shipped and stored in tank cars, drums, or other metal containers, the greater percentage of turpentine is still shipped and stored in wooden barrels. Especially is this true with regard to the turpentine shipped or stored by the smaller operators. Leakage from the barrels has long been a serious and costly problem in the industry. During the year the bureau has initiated laboratory experiments with a view to so improving the gluing of barrels that these losses and expenses may be reduced. The work has resulted in the development of a gluing process which promises to be quite effective for the purpose, and which will be submitted to actual trial during the coming year.

STATISTICS

At the urgent request of representatives of the industry, statistics to show the total quantities of rosin and turpentine used in 1927 and stocks on hand in each of the using industries, at the primary ports and the chief distributing centers on March 31, 1928, and also a report on the number of new cups sold for use during the year, have been made public. These figures, which are the bureau's compilation of those voluntarily supplied to it by individual users and manufacturers, are the only source of this information and serve to keep the naval-stores trade informed as to conditions. They are estimated to be between 90 and 95 per cent accurate.

EXHIBITS

Both alone and in cooperation with the Office of Exhibits of the department, the bureau has continued to build up its exhibits to show better naval-stores practices and uses of the products. These are found helpful in the bureau's technological work in the field and also in informing users of naval stores as to methods and difficulties of production.

SPECIFICATIONS

The bureau has continued to cooperate with the Federal Specifications Board, with the American Society for Testing Materials, and with the Association of Official Agricultural Chemists in the preparation of specifications and standards of quality for naval-stores products.

NAVAL-STORES HANDBOOK

Further progress has been made on the handbook designed to contain technical, industrial, agricultural, and general information useful to producers. This handbook is being prepared in cooperation with other interested bureaus of the department, and the indications now are that it will be ready for printing within the next fiscal year.

PAPER RESEARCH

The Bureau of Chemistry and Soils has long recognized the need for research work to determine the factors which control the suitability of paper and fiber board for the various uses to which they are put and especially for research on the factors that control the durability of paper used for permanent and legal records, such as historical documents, scientific articles, and particularly Federal, State, county, and city records, including deeds, wills, and other papers dealing with property.

The bureau has attacked these problems from the point of view of the paper maker and of the user of paper. It has studied means for elimination of waste in raw material during transportation, storage, and handling. It has realized that there is wide opportunity for saving in making and using the billion dollars' worth of paper now being produced annually in this country. In the past, the bureau has published a number of articles dealing with the general subject of paper and paper utilization and preservation. During the past year, in cooperation with the Government Printing Office, it has entered into a more extensive and vigorous investigation especially of the deterioration and discoloration of paper, with special reference to paper intended for purposes where great durability is required.

The work so far done has developed very definitely the fact that the presence in considerable quantity of sulphuric acid, which may come from the use of excessive quantities of alum to precipitate rosin size, is one of the outstanding causes of the deterioration of paper, and that for durable paper a minimum quantity of alum should always be used, since the free sulphuric acid which results from the reaction between the alum and the paper itself is never, under the present conditions of paper making, entirely removed from the paper, but remains in it to work its destruction throughout the life of the paper. It has been shown, too, that exposure to light of paper containing considerable quantities of free sulphuric acid hastens its deterioration.

A number of other interesting and important indications have already been developed in this work, which is being vigorously continued in cooperation with the Government Printing Office.

PAPER AND BOARD FROM FARM BY-PRODUCTS

Careful investigation of the utilization of cornstalks for paper making and several other uses has been made by the bureau during the past year. A representative of the bureau has conferred with manufacturers of pulp, paper, and board, and others interested in the utilization of cornstalks and collected samples of products pre-

pared from cornstalks and other crop by-products.

Samples of paper made from approximately 65 per cent cornstalk pulp and 35 per cent chemical wood pulp and used for special editions of newspapers and farm journals were examined in the laboratory in comparison with regular standard print newspaper. It was found that the paper containing cornstalk pulp had a greater bursting strength and folding endurance than standard newsprint paper, but that the latter was more opaque and had better printing qualities.

One commercial plant using cornstalks is turning out a good fiber board, and prospects for financial success in making board from cornstalks appear bright where conditions are favorable. Good building, insulation, and other special types of board continue to be produced from wheat straw, flax straw, sugarcane bagasse, waste wood, and old paper, apparently with financial success.

To meet the demand for information on the subject, an 18-page mimeographed circular, Farm Wastes for Paper and Board Making, has been issued. This circular summarizes the experiments of the Department of Agriculture and of others on this subject.

UTILIZATION OF CORNSTALKS

Studies have been made relative to the utilization of cornstalks along various lines, with particular reference to corn-borer control. Special consideration has been given the possibility of using them when properly prepared as fuel, as an absorbent for various purposes, as a constituent of linoleum, of plastics, and for those purposes for which wood flour or sawdust is now largely employed. Progress in the development of small-scale plants for the production of gas and other products from crop wastes by means of destructive distillation has been followed closely, and one manufacturer of such equipment has agreed to supply the bureau with an outfit for experimental work on cornstalks and other crop wastes.

The bureau has kept in close touch during the year with the plants making paper pulp from cornstalks, with paper mills experimenting in the use of cornstalk pulp in newsprint and book papers, with plants making fiber board from cornstalks, with plants making fiber board from wheat straw, and with plants producing gas, carbon, and other products from crop waste. These investigations have confirmed the Department of Agriculture's previous findings that farm by-products can be used for making many different products, and the indications are that some products can be made economically and profitably.

FARM FABRICS

PRESERVATIVE TREATMENTS

Work on the preservative treatment of canvas has been limited to keeping informed with regard to the commercial treatments offered to make canvas water and mildew resistant. A number of samples of canvas treated by commercial processes have been tested for mildew resistance in comparison with mineral-dyed khaki and gray duck. Some of these were found to be about as resistant as mineral-dyed khaki; others were found to be of little value or no better than the treatments devised and made public by the bureau.

FERTILIZER BAGS

The rapidity with which bags containing fertilizer deteriorate has long been a serious problem to the manufacturers of fertilizer and to the farmer. The bureau has started research work the object of which is to devise treatments to increase the resistance or to prevent the rapid deterioration of such bags. Preliminary results so far obtained indicate that bags made either of burlap (jute) or of cotton are rapidly attacked under favorable conditions either by dilute sulphuric acid or by freshly made superphosphate (acid phosphate); that if the temperature is kept low the deterioration is retarded; that the fluorine contained in superphosphate is an active agent in hastening deterioration; and that there is little difference in the rate of deterioration of cotton and jute bags.

TOBACCO SHADE CLOTH

Weather-exposure tests on tobacco shade cloth treated with lead chromate commercially and on samples of shade cloth, canvas, and sheeting treated in the laboratory were completed this year. It was found that the treated cloths had stood up well, confirming the findings of previous small-scale experiments that the chromate-treated shade cloth will be serviceable for two or possibly three years, thus decreasing materially the

cost to the tobacco growers of shade cloth.

Through consultation with the director of the tobacco substation of the Connecticut Agricultural Experiment Station, in cooperation with which this work on tobacco shade cloth is being done, it was found that the tobacco growers feel that there is need for further experimental work by the bureau with the view of developing a less expensive method for treating tobacco shade cloth. Work on such methods has begun and will be continued during the coming year.

MISCELLANEOUS

The bureau has continued to cooperate with the Federal Specifications Board in the preparation of specifications for the purchase of paper, paints, varnishes, linseed oil, leather and leather goods; with the Government Printing Office in the preparation of standards and specifications for the purchase of paper for Government use and for the purchase of leather and leather goods for the public printing and binding; with the Association of Official Agricultural Chemists in the study of methods for the examination of tanning materials, leather and leather goods, turpentine, and rosin; with the American Leather Chemists Association in the study of methods for the analysis of tanning materials, leather, and tannery raw materials; with the American Society for Testing Materials in the study of methods of examination and standards and specifications for paints, paint materials, turpentine, and rosin; with the American Chemical Society in the preparation of specifications for the paper used in its publications; and with the departments of the Federal Government and of States on subjects that come within the province of the bureau.

INSECTICIDE INVESTIGATIONS

The loss caused by injurious insects in the United States is estimated to be fully $2,000,000,000 annually, and their control is a matter of vital economic significance, as evidenced by the recent depredations of the Mediterranean fruit fly and yearly losses from other better-known species of insect pests.

INSECTICIDAL PLANTS

Work has been continued during the year on various insecticidal plants. The chemical constitution of rotenone, which is the insecticidal principle of *Derris elliptica*, has been closely investigated. It is now believed that its structure can be determined.

Following an invitation from a commercial firm, the bureau has agreed to assist a committee representing insecticide manufacturers interested in pyrethrum flowers in testing chemical methods for the evaluation of pyrethrum. Over 11,000,000 pounds of pyrethrum flowers, with an approximate value of $2,500,000, are imported annually into the United States, and there is great need for a chemical method of assaying them.

Through the aid of the consuls of the State Department, the division has been placed in touch with botanists and collectors of crude drugs in South America and Central America. Through these connections it is hoped to secure samples of certain rare plants which have been found to possess very great insecticidal value. As soon as they are received, an effort will be made to isolate and determine the nature of the insecticidal principles present in these plants.

SPRAY RESIDUES INVESTIGATIONS

The problem of removing arsenical residue from sprayed fruit is a matter of great importance to the fruit growers and the public, as the metallic residues caused by overspraying or late spraying of fruit constitute a definite health hazard. The bureau has been successful in finding an improved washing solution for the removal of spray residue from apples. It has been found that the addition of certain salts, such as sodium chloride and sodium sulphate, greatly enhances the solvent action of hydrochloric acid for lead arsenate. It is believed that this improved washing solution will soon come into commercial use and result in the saving of many thousands of dollars to the fruit industry.

At Wenatchee and Yakima, Wash., the field work of this bureau in cooperation with the Bureaus of Entomology and Plant Industry has been so heavy that it was necessary to send two additional workers into the field for several months. Over 5,000 samples of apples were analyzed at Yakima and Wenatchee by chemists of the bureau in assisting the Bureau of Plant Industry.

PREPARATION OF FLUORINE INSECTICIDES

Certain of the fluorine compounds have recently been proved more effective than lead arsenate in controlling

the European corn borer. The work of the bureau in preparing these compounds has been successfully continued. It was also ascertained by experiments at Yakima, Wash., that certain fluorine compounds appear promising as substitutes for lead arsenate for the control of the codling moth. It is believed that the compounds of fluorine upon which the bureau is experimenting now offer the best chance of an inorganic substitute for lead arsenate.

TESTS WITH NEW FUMIGANTS

Particularly interesting are the results that have been obtained on mixing carbon dioxide with certain fumigants. The addition of about 10 per cent by volume of carbon-dioxide gas in a fumigating chamber not only enhances the insecticidal efficacy of the fumigant—such as, for example, ethylene dichloride—but also greatly shortens the necessary period of exposure. This new discovery has great commercial possibilities. Widespread interest has been attracted to the work of the bureau on ethylene dichloride as a clothes-moth fumigant. Recent work with ethylene oxide indicates that when used in vacuum fumigating apparatus it is even more toxic than hydrocyanic acid against certain insects.

ANALYTICAL WORK

Much analytical work is performed for the Bureau of Entomology. During the past year samples of the following materials have been submitted for examination: Lead arsenate, calcium arsenate, tobacco powder, Derris root, Derrisol, pyrethrum powder, pyrethrum extract, various fluorides and fluosilicates, oils to be used in making oil emulsions, soaps, etc. Many determinations of arsenic upon samples of apples, blueberries, beans, and other products which have been sprayed or dusted by entomologists at various field stations have been made.

OTHER INVESTIGATIONS

Investigations on pyridine derivatives have continued during the past year, and the special work on neonicotine is nearing completion. Four articles on this project have been published by scientists of this bureau in the journal of the American Chemical Society during the past year. Early in the year certain derivatives of formic and chloroacetic acids were prepared, also compounds containing the ethylene oxide linkage. These compounds were tested by a representative of the Bureau of Entomology upon *Aphis rumicis*, but none was found to be sufficiently toxic to justify further work with them.

In connection with arsenical studies a report will soon appear on the work of sampling cleaned apples for the determination of arsenical-spray residue. An investigation is also being made on the arsenic in manufactured forms of tobacco. A preliminary examination of cigars shows that arsenic may be present to the extent of 0.3 grain As_2O_3 per pound; this is thirty times the British tolerance for arsenic for apples.

OIL, FAT, AND WAX INVESTIGATIONS

Fats and oils from new sources are being studied by the oil, fat, and wax laboratory to discover the purpose they may serve and to determine whether or not it is feasible to produce them commercially. Much attention is also being paid to the investigation of the composition of commercial fats and oils. In addition to these studies, attention is given to new research methods and to those for testing the purity of fats and oils.

REINDEER FAT

Five samples of Alaskan reindeer fat were examined in collaboration with the Bureaus of Animal Industry, Home Economics, and Biological Survey. The composition as well as the characteristics of the reindeer fat have been determined. Unlike the fat from ordinary farm animals, reindeer fat was found to contain a small but noteworthy quantity of arachidic acid as glyceride. In some respects it resembles beef tallow and can be used for the same purposes—namely, edible and technical uses.

NEW SOURCES OF OILS

In California walnut oil is now being pressed from the broken or otherwise unsalable "meats" obtained from the shelling plants. After the investigation of this oil it was pointed out that on account of its high iodine number it was particularly suitable for use as a paint oil. Previously most of it, if not all, was sold to the soap factories.

Experiments were made which indicated that avocado oil would, if of good quality, be suitable for local use in California or Florida as a cooking oil. Its smoking temperature was found to be slightly above that for olive oil.

The investigation of grapefruit-seed oil has begun. The air-dried seed contain somewhat more than 30 per cent of an oil which has been found to belong to the semidrying class of oils.

WALNUT OIL

A thorough examination was made on an authentic sample of commercial walnut oil expressed in California. The characteristics and composition were determined. This is the first extensive study made of this oil which for a great many years has been used in Europe and Asia for edible purposes, as well as for making paint, particularly artists' colors. It was found that the California walnut oil was outstanding in its high iodine number, much higher than that usually found in Europe.

SAFFLOWER-SEED OIL

Through the efforts of the Bureau of Plant Industry an increasing acreage is being planted to safflower in various States of the Northwest, and before long a new American industry will have been established.

The oil, which was expressed from seed grown in Montana, has been examined and its composition determined. It is a good drying oil and is suitable for use in the manufacture of paints, varnish, and linoleum; it is also edible. When the oil is heated for several hours from 300° to 310° C. it polymerizes and solidifies to a very stiff elastic mass, for which some practical use may be found.

CHIA-SEED OIL

The characteristics and the composition of chia seed have been determined. The seed yields a strong drying oil, which is well suited for use in the manufacture of paints and varnishes, as well as oilcloth and linoleums.

PALM OIL

Enormous quantities of palm oil are used in the United States by the soap makers and the tin-plate industry. With the improvement in the quality of the product, particularly that from Sumatra, increasing quantities of palm oil are being used in the manufacture of margarin, for which it is well adapted.

The laboratory was especially fortunate in receiving a sizable sample of palm oil of good quality from the Belgian Congo. The characteristics and composition of this oil have been determined. In view of the fact that commercial palm oil is produced in various countries, and often from different varieties of the African palm, *Elois guineensis*, and because some varieties differ greatly from each other in many respects, it is important that this study should be extended to include the palm oils from the important producing countries. These results will be of particular value to the soap makers and margarin manufacturers, as well as to those engaged in the cultivation of the palms, if the results indicate that the oil from certain varieties is superior in any marked respect to that from others.

NUTRITIONAL INVESTIGATIONS

PROTEIN INVESTIGATIONS

The general importance of a knowledge of the chemical composition and properties of protein in judging the value of animal feeds and food for man is so generally recognized as to need no emphasis. Statistics show that the value of protein concentrates, or meal, used in the United States for stock feed amounted in 1927 to $3,500,000,000. Nearly all the agricultural products that are used for food and feedstuffs are valued to a greater or less extent for their protein content. Recently, in the feed industry, the practice of buying and selling certain feeds on the basis of their protein content has become prevalent. Protein is one of the most important of the different food factors; yet not all proteins have the same nutritive value. Some are lacking in their content of certain nutritionally essential amino acids, without which young animals will not grow and adult animals fail to maintain a nutritively normal condition. On the other hand, there are proteins that contain relatively excessive amounts of these same amino acids. A knowledge, therefore, of the composition of different proteins is essential in the mixing of different feeds to give a mixture that will be the more efficient for animal production and provide the best and most economical utilization both of feedstuffs containing proteins of poor quality and those of unusually high food value.

Many unsolved problems of great importance depend for their solution upon a more complete knowledge of protein chemistry. In the baking industry these involve such subjects as strong and weak flours and the cause

of bread growing stale. Other problems which are linked up with protein chemistry are the keeping quality of fruit juices; the proper place in the diet of vegetables, tubers, and fruits; the effect of storage upon different food commodities, as well as studies of the cause and treatment of certain diseases involving questions in serology, immunity, and the action of antitoxins.

Practically no knowledge is available concerning the proteins of sweetpotatoes. Their extensive cultivation and use as food in the United States emphasize the need of undertaking work to secure information concerning their proteins. Accordingly, work is in progress to this end, and many preparations of purified proteins from different varieties of sweetpotatoes have been obtained for the first time. These proteins are being studied with reference to their properties, elementary composition, and amino-acid content. Evidences have been obtained of important changes that occur in the proteins during the storage of the sweetpotatoes, wh'ch may also be of great importance in connection with the storage of white potatoes and other roots and tubers that are used for food. Although the amount of protein in roots and tubers is low compared with that in seeds and some other foods, their extensive use as a food and the possibility that their protein may possess unusually high food value or have certain peculiar properties might make them rank high as a source of food protein.

Work formerly done on the proteins of peanuts, the results of which are described in 13 publications, has demonstrated the high nutritive value of these proteins. Some particulars regarding the properties of arachin and conarachin, the two chief proteins of peanuts, and the proportions in which they are present in the peanut, were not ascertained in the former studies. In view of the importance of peanuts as a crop furnishing feed for animals and having a wonderful potential value as a food for man, both from the standpoint of the oil and as a source of protein, work on peanuts has been resumed by this bureau.

The avocado, also known as the alligator pear, is steadily growing in favor and importance as an article of food. A native, tropical fruit of Latin-American origin, its cultivation in the United States, which has steadily increased, has been made possible by the introduction into this country of the most suitable varieties by the United States Department of Agriculture. The proteins of this group have been isolated and their composition determined in this bureau. This is the first time that the protein from any fruit has been isolated and its elementary composition and amino-acid content determined. Feeding experiments have been made to get further data on the nutritive value of these proteins and to determine the vitamins in the fruit.

Prerequisite to the development of further information along certain lines of protein chemistry is the obtaining of more data regarding the action of dilute alkalis on proteins. One of the two most important proteins of wheat—namely, glutenin—is isolated by first extracting gluten with dilute alkali. There is some evidence that the alkali used in this process produces fundamental changes in the protein. Consequently, the isolated glutenin as usually prepared probably does not represent the native protein as it existed in the seed. Determinations of the properties and composition of the isolated protein may therefore be misleading when taken to represent those of the glutenin as it exists in the wheat kernel.

Conflicting statements regarding the percentages of some of the nutritionally essential amino acids in casein, the chief protein of milk, have been reported by different investigators, due probably to the fact that the casein used by different analysts had undergone various changes produced by the alkali used in its preparation. In view of the importance of this question, studies have been undertaken and are in progress to investigate the action upon proteins of dilute alkalis under different conditions, a problem in protein chemistry concerning which our knowledge is at present very meager.

Investigations have continued on the glutelins of cereals. The glutelins in corn and rye have been isolated and their properties and content of amino acids determined. Work is in progress on the glutelins of buckwheat and certain varieties of sorghum.

Experiments with cows and dogs have shown that lignin, a substance entering largely into the composition of plants and which therefore constitutes a large part of the diet of herbivorous animals, is metabolized

and that the lignin in the diet contributes to the hippuric acid that is eliminated in the urine.

GOSSYPOL

During the past year additional data have been gathered on the retardation of growth of rats when differing amounts of gossypol were added to a satisfactory diet. Rats show a marked difference in response depending upon whether 0.125, 0.150, or 0.175 per cent of gossypol is added to the diet. Of three cottonseed meals prepared by three different methods, tested biologically for toxic effect of gossypol, two showed practically no toxicity and one showed appreciable toxicity. This work indicates that properly conducted feeding experiments with rats may be as accurate in determining small amounts of gossypol in cottonseed meal as the chemical methods now available.

VITAMINS

Work has been continued on a variety of foodstuffs to estimate the quantity of vitamins which they contain and to extend our knowledge concerning the properties of vitamins and develop more satisfactory methods for their assay.

A preliminary communication describing a technic whereby the storage of vitamin A in young rats may be controlled and maintained at a comparatively uniform level has been published. By means of this technic the time and labor required for the determination of vitamin A in foods and commercial preparations can be materially decreased.

Other studies have shown certain defects of the United States Pharmacopœia vitamin A assay of cod-liver oil. The United States Pharmacopœia X method does not eliminate vitamin D as a growth-promoting factor. When this factor is provided ophthalmia usually develops before growth ceases, so that the curative test can not be carried out on an animal free from disease.

In curative tests for vitamin A, although observations on the presence and change of severity of ophthalmia are essential, the growth response seems to offer a more tangible means of judging vitamin A potency. The vitamin A potency of a sample of butterfat was found to be approximately one-fifteenth of that of a good grade of cod-liver oil.

VITAMINS IN THE AVOCADO

Work on the avocado which was completed during the year failed to reveal demonstrable amounts of vitamin A or D in the oil obtained from avocados. A dry, fat-free meal prepared from the pulp was tested for vitamins B and G. The meal was prepared by drying the pulp of the fruit in a current of air, and the oil was then expressed by pressure. The press cake was extracted with petroleum ether and again dried. This material is an excellent source of both vitamins B and G, being about half as potent as an excellent quality of dried yeast.

VITAMINS IN SUGARCANE JUICE

Investigations on the vitamins in sugarcane juice which have been in progress intermittently during a period of years were completed during the year. Although containing vitamins A, B, and C, sugarcane juice can not be considered as a rich source of these vitamins. It contains no significant amount of vitamin D. Juice obtained from the upper portions of cane stalks was found to contain more vitamin B than that obtained from the lower portions of the same stalks. This vitamin was also found in larger quantity in juice expressed under the high pressure of a hydraulic press than in juice expressed at lower pressure in an experimental sugar roller mill. Tests made on cane sirup, cane cream, and samples of Louisiana and Porto Rico blackstrap molasses showed that these products contained little or no vitamin B.

VITAMINS IN FISH OILS

Three samples of burbot-liver oil, and one each of shark-liver and pufferfish-liver oil, have been examined for both vitamins A and D during the past two years. The work has been completed, and it is planned to publish these results jointly with the oil, fat, and wax laboratory and to include their data on the chemical and physical properties of burbot-liver oil.

VITAMIN STUDIES ON HYBRID CITRUS FRUITS

Evidence has been obtained showing that the tangelo, a hybrid resulting from a tangerine and grapefruit cross, inherits the characteristics of the latter parent with respect to vita-

min B. This would indicate that vitamin-B production is controlled by a single or limited number of genetic factors in the plant. If so, it should be possible to breed plants for a high vitamin-B content. For the continuation of these studies, there have been received from the Bureau of Plant Industry kumquats, limes, and a hybrid called limequat, produced by crossing the kumquat and the lime. The juices of these fruits will be tested for vitamin B as soon as other experiments now under way are terminated.

TECHNIC OF VITAMIN ASSAY

During the past year data have been obtained showing that vitamin A can be determined quantitatively by a preventative technic in which only one dose of the substance is fed. In many cases such a determination offers many advantages over the well established curative method commonly used. Studies are being continued which may establish further limitations as to commonly accepted methods.

VITAMIN ASSAY OF COMMERCIAL PRODUCTS

The results of the investigation of the vitamin content of 29 samples were reported to the drug-control laboratory during the past year. Twenty-five of the products were tested for vitamin D and 14 for vitamin A. Considerable attention has been devoted to liquid preparations containing 15 to 20 per cent of alcohol, which are claimed to contain extracts or concentrates of cod-liver oil.

EFFECT OF ETHYLENE GAS ON VITAMINS OF TOMATOES

In connection with work being done by the Food Research Division of this bureau on the effect of ethylene gas on tomatoes as used commercially in bringing about a forced coloring, feeding experiments have been conducted to determine what effect, if any, the gas treatment may have on vitamins A, B, and C. For this purpose four different lots of tomatoes gathered at definite stages of development were divided each into two portions. One portion was subjected to the ethylene treatment and canned according to usual cannery practices. The other portion, untreated with ethylene, was similarly canned. The vitamins were also determined in untreated mature tomatoes allowed to ripen naturally on the vines.

The results of the feeding experiments showed but little difference, if any, in the vitamin content of the treated and untreated immature tomatoes. A superiority, however, was found in the vitamin content of the naturally vine-ripened tomatoes over that of the immature tomatoes either treated or untreated.

SOIL INVESTIGATIONS

A. G. McCall, *Chief*

THE SOIL SURVEY

Studies of soils in the field have been pursued much more extensively in the United States than in any other country in the world. It has long been accepted as a fundamental principle in the soil survey that the bureau is under obligation to obtain as broad a knowledge of the soils of the world as possible. This position has been assumed partly because of our interest in soil science as a whole and partly because of the tremendous practical importance of the agricultural industry.

Since the inauguration of the Soil Survey a little more than a quarter of a century ago, soil areas have been surveyed and mapped in every State and Territory in continental United States, in Porto Rico, Panama Canal Zone, Cuba, Central America, and South America.

During the past fiscal year soil-survey work was carried out in 72 separate areas distributed over 28 States. By this policy of wide distribution of projects each year there is presented an opportunity for studying soils under a wide variety of conditions and thereby extending our knowledge of the more important soil regions of the country.

The work of the Soil Survey for the past year is summarized in Tables 1 and 2. Table 2 also presents a recapitulation of the areas surveyed since the inception of the work 30 years ago. Detailed surveys aggregating 20,650 square miles and reconnaissance to the extent of 2,010 square miles were covered during the year, bringing the total acreage for the detailed survey to almost 500,000,000 and the reconnaissance survey to slightly more than 383,000,000 square miles.

TABLE 1.—*Individual areas surveyed and mapped during the fiscal year ended June 30, 1929*

State	Area	Area surveyed		State	Area	Area surveyed	
		Square miles	Acres			Square miles	Acres
Ala	Coosa County	655	419,200	Minn	Hennepin County	[1] 348	222,720
	Mobile County	[1] 367	234,880		Houston County	391	250,240
Ariz	Yuma-Wellton area	648	414,720	Miss	Hancock County	[1] 76	48,640
Calif	Capistrano area	74	47,360	Mont	Lake County (part of)	100	64,000
	Oceanside area	560	358,400		Milk River area	[1] 263	168,320
	San Luis Obispo area	587	375,680	Nebr	Cedar County	735	470,400
Colo	Greeley area	540	345,600		Dixon County	225	144,000
Ga	Hart County	164	104,960		Knox County	189	120,960
	Jefferson County	220	140,800		Pierce County	[1] 345	220,800
	McIntosh County	[1] 299	191,360		Saline County	[1] 111	71,040
	Worth County	[1] 104	66,560		Stanton County	106	67,840
Idaho	Gooding area	279	178,560	N. Mex	Socorro and Rio Puerco area	76	48,640
Ind	Blackford County	168	107,520	N. Y	Delaware County	180	115,200
	Pike County	65	41,600		Nassau and Suffolk Counties	[1] 32	20,480
	Rush County	409	261,760	N. C	Craven County	[1] 401	256,640
Iowa	Butler County	[1] 443	283,520		Gates County	[1] 289	184,960
	Calhoun County	82	52,480		Macon County	165	105,600
	Guthrie County	595	380,800		Person County	[1] 292	186,880
	Pocahontas County	[1] 94	60,160		Watauga County	[1] 107	68,480
	Poweshiek County	443	283,520	Ohio	Brown County	290	185,600
	Sac County	[1] 283	181,120		Licking County	[1] 243	155,520
Kans	Crawford County	[1] 491	314,240		Ottawa County	[1] 44	28,160
	Johnson County	[1] 220	140,800	Oreg	Columbia County	[1] 192	122,880
	Marion County	95	60,800	Pa	Tioga County	[1] 650	416,000
	Neosho County	51	32,640		Wyoming County	92	58,880
Md	Anne Arundel County	[1] 375	240,000	P. R	San Juan area	110	70,400
	Calvert County	[1] 124	79,360	S. C	Greenwood County	473	302,720
	Caroline, Queen Annes, and Talbot Counties	164	104,960	Tex	Frio County	[1] 514	328,960
Mass	Franklin County	70	44,800		Galveston County	213	136,320
	Hampshire and Hampden Counties	[1] 510	326,400		Polk County	[1] 359	229,760
Mich	Alger County	[1] 735	470,400		Potter County	[1] 814	520,960
	Branch County	[1] 102	65,280	W. Va	Hardy County	[1] 514	328,960
	Eaton County	95	60,800	Wis	Brown County	252	161,280
	Iron County	241	154,240		Vernon County	[1] 275	176,000
	Luce County	115	73,600	Wyo	Basin area	[1] 384	245,760
	St. Clair County	[1] 333	213,120		Total	20,650	13,216,000

[1] These figures do not include portions of these areas surveyed in preceding years.

TABLE 2.—*Areas surveyed and mapped in the several States during the fiscal year ended June 30, 1929, and areas previously reported*

DETAILED

State or Territory	Work during 1929	Work previously reported	Total		State or Territory	Work during 1929	Work previously reported	Total	
	Square miles	*Square miles*	*Square miles*	*Acres*		*Square miles*	*Square miles*	*Square miles*	*Acres*
Ala	1,022	52,011	53,033	33,941,120	N. H		1,411	1,411	903,040
Ariz	648	2,791	3,439	2,200,960	N. J		9,895	9,895	6,332,800
Ark		15,547	15,547	9,950,080	N. Mex	76	815	891	570,240
Calif	1,221	29,330	30,551	19,552,640	N. Y	212	26,071	26,283	16,821,120
Colo	540	3,904	4,444	2,844,160	N. C	1,254	40,932	42,186	26,999,040
Conn		1,704	1,704	1,090,560	N. Dak		16,878	16,878	10,801,920
Del		2,276	2,276	1,456,640	Ohio	577	15,144	15,721	10,061,440
Fla		15,160	15,160	9,702,400	Okla		6,540	6,540	4,185,600
Ga	787	33,315	34,102	21,825,280	Oreg	192	13,938	14,130	9,043,200
Idaho	279	10,319	10,598	6,782,720	Pa	742	16,903	17,645	11,292,800
Ill		6,770	6,770	4,332,800	P. R	110	330	440	281,600
Ind	642	16,848	17,490	11,193,600	R. I		1,085	1,085	694,400
Iowa	1,940	42,356	44,296	28,349,440	S. C	473	23,989	24,462	15,655,680
Kans	857	12,076	12,933	8,277,120	S. Dak		8,286	8,286	5,303,040
Ky		5,020	5,020	3,212,800	Tenn		11,198	11,198	7,166,720
La		16,769	16,769	10,732,160	Tex	1,900	50,058	51,958	33,253,120
Me		2,197	2,197	1,406,080	Utah		2,419	2,419	1,548,160
Md	663	12,226	12,889	8,248,960	Vt		1,175	1,175	752,000
Mass	580	7,604	8,184	5,237,760	Va		10,072	10,072	6,446,080
Mich	1,621	22,558	24,179	15,474,560	Wash		10,752	10,752	6,881,280
Minn	739	8,963	9,702	6,209,280	W. Va	514	20,530	21,044	13,468,160
Miss	76	29,139	29,215	18,697,600	Wis	527	24,742	25,269	16,172,160
Mo		37,177	37,177	23,793,280	Wyo	384	1,956	2,340	1,497,600
Mont	363	1,338	1,701	1,088,640					
Nebr	1,711	50,258	51,969	33,260,160	Total	20,650	753,427	774,077	495,409,280
Nev		652	652	417,280					

RECONNAISSANCE

Alaska		31,915	31,915	20,425,600	Ohio		41,420	41,420	26,508,800
Ark.-Mo		58,000	58,000	37,120,000	Pa		41,405	41,405	26,499,200
Calif		32,135	32,135	20,566,400	S. Dak		41,400	41,400	26,496,000
Kans		39,960	39,960	25,574,400	Tex		152,855	152,855	97,827,200
Mich		1,322	1,322	846,080	Vt	105		105	67,200
Minn		1,923	1,923	1,230,720	Wash		16,540	16,540	10,585,600
Mont	1,905	31,919	33,824	21,647,360	Wis		14,425	14,425	9,232,000
Nebr		53,064	53,064	33,960,960					
N. Dak		39,240	39,240	25,113,600	Total	2,010	597,523	599,533	383,701,120

In addition to the extension of soil mapping, there are many ways in which the soil survey has been of inestimable value. The use of it has saved large sums of money and furnished information for the location of substations, the extension and development of certain crops, and the study of soil erosion.

In Alabama, when the State officials desired to purchase land upon which to locate the penitentiary farm in the southwestern section of the State, they called upon the State soil-survey man, who by the use of a soil map of that region, was able to select certain types of soil which would represent some of the best land in the coastal plain of Alabama. By his knowledge and by the use of the soil-survey map he saved the State from $30,000 to $50,000 on this purchase.

During the past year the director of the Alabama Experiment Station at Auburn has made valuable use of the soil survey, and particularly of the State soil expert, in locating and establishing several substations. It was the desire of the director that these stations be located in various parts of the State and upon definite and large soil areas so that the results obtained from their experiments would be applicable to the greater part of the State.

After the advent of the boll weevil throughout the northern portion of the coastal plain and southern part of the piedmont of Georgia, the farmers and extension people began to look around for other crops that could be profitably produced. The soil-survey maps of various counties in Georgia showed extensive areas of soils in the State

similar to the soils in North Carolina and South Carolina where tobacco and, to a less extent alfalfa, have been successfully grown. The development of the tobacco interest in the last few years in the State of Georgia is due largely to knowledge obtained by the soil survey.

The soil-survey maps reveal the boundaries of the sand-hill region in North Carolina and the northern part of South Carolina and to a less extent in Georgia. When the director of the Clemson College Experiment Station was apprised of the large acreage of this sandy land in South Carolina, and when it was considered that only a very small percentage of it was used for the production of crops, it was deemed wise to establish an experiment station somewhere in the sand-hill region. Consultation with the soil-survey men and a study of the soil maps made it possible to locate a substation on a soil that is typical of the great sand-hill region, thereby insuring a wide application of the results obtained.

The North Carolina Experiment Station has in the last few years, in addition to the work at its six substations, extended its plot work to include the large and important soil types in the State as revealed by the soil survey. It has been found that the greater part of the clovers and alfalfa produced in North Carolina are confined to certain well-defined and recognized soil types which are better adapted to their production than the general run of soils in the State.

The Reclamation Service has made use of the soil survey during the past year in its investigations of certain tracts of land in the South with a view to the establishment of colonization projects. The location and character of the soil, as indicated on the map, would in many instances be sufficient to determine whether or not the land in question was worthy of consideration.

In the soil-survey reports are described those soils which are subject to severe washing and erosion. It has been found that in the same region some soils erode much more severely than others, the difference being due to the physical character of the soil throughout its profile.

Progress has been made in the classification of organic soils, commonly known as muck and peat. This classification is based upon physical characteristics such as may be readily recognized by the soil experts, and so far as possible is correlated with native vegetation in order to facilitate mapping. While the organic soils are difficult to map, because of the swampy nature of the terrain in most areas, it is felt that the classification meets a need for detailed information regarding these deposits, valuable not only to agricultural interests, but for industrial purposes as well. The system of classification as now worked out has been used in 18 counties in Michigan, 3 counties in Wisconsin, and 1 county in Minnesota.

The work in cooperation with the Michigan Land Economic Survey continues satisfactorily. This survey is considered one of the most valuable of its kind in the country. Interesting correlations between soils and native vegetation are being brought out in this study, since not only the soils but the land cover is being mapped in detail. The economic survey produces three sets of maps, one of soils, one of cover (or vegetation, whether native or farm crops), and one of ownership. These maps also bring out correlation between soils and land utilization in an accurate and detailed way.

An interesting side light on the survey as a training course for soils workers is the plan of one of the midwestern experiment stations whereby all men chosen to engage in any sort of soils work for the station are required to have had some field experience on the soil survey. Men with soil-survey training are also engaged by the State highway department for subgrade investigations.

Engineering concerns engaged in laying pipe lines in the vicinity of Chicago are using the soil maps in connection with laying out their work and preparing estimates.

In the North Central and Northeastern States there is increased interest in soil-survey work. Cooperation has been established in Vermont and Kentucky and soil-survey work resumed after a lapse of many years.

A new interest in soil classification and mapping has developed in connection with reforestation. It is recognized that soil survey is the basis of land classification, which should precede all systematic plans for reforestation and the establishment of State and Federal forest areas.

SOIL EROSION AND MOISTURE CONSERVATION RESEARCH

Soil impairment by erosion is one of the most important problems confronting American agriculture. The

losses resulting from unrestrained erosion amount to many millions of dollars annually. The value of the plant-food materials removed from the cultivated and pasture lands of the United States every year has been conservatively estimated to be in excess of $2,000,000,000. Of this amount there is evidence to indicate that many millions of dollars can be charged up as a direct tangible loss to the farmers of the Nation. In this connection it must be remembered that it is not the plant food alone that is removed by rain wash, but that the solid soil material itself is also washed away. The plant-food elements removed from the soil by growing crops can be restored in the form of fertilizers and manures, but the soil that is washed from the fields can not be restored except by those exceedingly slow natural processes of soil formation that require in many instances many centuries for the building up of a comparatively thin layer of soil from the underlying parent material. A very considerable part of erosional wastage in addition to being an immediate loss to the farmer is at the same time a loss to posterity. When the mellow topsoil, with its valuable humus and nitrogen, is gone, there is exposed in its place the subsoil, which is less productive, less permeable, and less absorptive of rainfall. Usually this exposed material is heavier than the original soil, stiffer and more difficult to plow, less permeable to plant roots, and less absoptive of rainfall. Soil erosion and water conservation are closely interrelated since methods designed to prevent destructive erosion, will in a large measure, function to conserve soil moisture.

The work of the Soil Survey of the Bureau of Chemistry and Soils, the investigations conducted by the Bureau of Public Roads, and the forestry and range-management studies carried out by the Forest Service have all served to indicate the wide extent to which the lands of the United States have been subjected to destructive erosion. A single county in the piedmont region of South Carolina was found by actual survey to contain 90,000 acres of land formerly cultivated which has now been permanently ruined by erosion. In another county in the Atlantic coastal plain of Georgia 60,000 acres of formerly rich soil is found to have been gullied beyond repair. In the brown-loam belt along the Mississippi River, county after county has been found to contain 10,000, 20,000, or 30,000 acres of land from which agriculture has been driven by reason of destructive and unrestrained erosion. Not only have the uplands been widely and disastrously dissected, but large areas of good alluvial land have in many cases been buried beneath infertile sands washed out of the upland gullies. Stream channels have been choked with erosional débris to such an extent that overflows have become exceedingly common and large tracts of formerly productive soil are now mapped as swamp land. These are only a few examples of the eroded areas that are to be found in practically all sections of the country.

During the past year a reconnaissance survey has been in progress for the purpose of locating and outlining the boundaries of the severely eroded areas in the United States. As a result of this survey, 18 districts have been recognized in which soil impairment by erosion has become a serious menace, and plans have been made to establish in each of these areas a field station at which erosion and moisture-conservation problems can be studied. This field work was inaugurated by the establishment of a station in cooperation with the Bureau of Public Roads, on a tract of 160 acres located about 4 miles south of Guthrie, Okla. By taking advantage of the immediately available provision of the appropriation act for 1930 it has been possible to establish stations and inaugurate work at similar stations located at Temple, Tex., on the black land and at Hays, Kans., on typical soil of that region of limited rainfall. At Guthrie and at Temple major emphasis is being placed on studies of erosional losses of the soil material, while at Hays emphasis will be given to moisture conservation as well as to sheet erosion.

SOIL-FERTILITY INVESTIGATIONS

The division of Soil Fertility conducts field, greenhouse, and laboratory studies pertaining to prominent soil types in relation to soil-fertility problems. The investigational work concerns itself with a study of the nature and constitution of organic constituents of the soil and their biochemical relationships; the hydrogen-ion concentration of different soil types; the composition of the soil solution in its relation to plant growth; the influence of fertilizers on crop production and on the quality of the products, involv-

ing protein, fat, starch, and other determinations; the composition of fertilizers; the influence of chemical salts of synthetic origin on plant growth; a study of toxic and beneficial compounds on plant development; and general field investigations with fertilizers on crop growth and production and other soil problems of an important character.

An increased demand for soil-fertility and fertilizer studies on prominent soil types has resulted in the establishment of field laboratories by means of which closer contact with soil-fertility problems can be maintained. These activities are reflected in the work on cotton root rot in Texas; on pecan soils in Louisiana and elsewhere in the pecan-growing belt; on sugar-cane soils in Louisiana; on sugar-beet soil types in a number of sugar-beet-growing States; and the cooperative studies at the sand-hill station near Columbia, S. C., dealing with soil improvement. In connection with these activities, field and laboratory work are in progress, and definite cooperation with the various industries involved has been established.

The field work to determine the fertilizer requirements of prominent soil types and the crops grown thereon is being enlarged in scope. This includes field studies with new nitrogen materials and concentrated fertilizers. As a result of these field investigations more definite recommendations as to the kind and quantity of fertilizer material to use on different soil types will be made possible. Of special importance has been the work with concentrated fertilizers, whose use is increasing because of a number of economic advantages they possess, among them lower hauling and freight charges as well as the fact that fewer bags are needed than for the same quantity of ordinary-strength fertilizers. In sections where long freight hauls are involved and the growing season is relatively short the use of concentrated fertilizers is increasing. The field work referred to has been very helpful in guiding farmers and their organizations in the selection and use of these more highly concentrated fertilizer materials. These newer materials and their mixtures present other problems including studies of methods of placement and distribution. Such problems are of particular importance on the light soils of the Atlantic and Gulf coastal plains regions, where large quantities of commercial fertilizers are used.

In addition to helpful findings on highly important nutritional problems on such soil types, the field studies have developed the desirability of determining the influence of certain chemical elements not heretofore associated with the feeding of plants in the ordinary sense. Over a considerable area of the United States, more particularly along the Atlantic and Gulf coastal plains, it appears evident that growing crops require more than the addition of fertilizers containing nitrogen, phosphoric acid, and potash salts. Under certain soil conditions it has been found that small applications of manganese salts have given striking effects; on other soil types salts of copper, zinc, boron, and iodine and of similar uncommon soil elements have given crop responses indicative of unusual functions in connection with crop growth and development.

While the fundamental facts connected with the physiological functions of these and other uncommon soil elements remain to be worked out, sufficient progress has been made to indicate the importance of such studies. Associated with such problems is that relating to synthetic fertilizer salts in which very little, if any, so-called impurities occur.

Whether the absence of such material will tend to interfere with plant growth and development, especially on light sandy soils, is being given consideration.

The present year marked the inauguration of cotton root rot investigations in Texas, to study soil-fertility factors as related to the root-rot disease. Field and laboratory studies are now in progress for the purpose of correlating soil characteristics with the prevalence of this disease. A laboratory has been established on the campus of the University of Texas, at Austin, and field experiments are now in progress at 12 locations in the black belt of Texas, extending from San Antonio to Greenville. A large number of fertilizers and chemicals are being studied to determine their influence on cotton root rot. Some of the physiological acid fertilizers and some nitrogen materials lessened the ravages of the root rot on some of the less alkaline soil types last season, but additional work is necessary before definite conclusions can be reached.

Fertilizer investigations on prominent soil types of the Southeastern States were inaugurated in 1918. This project embraces the conducting of fertilizer experiments on prominent

soil types with leading farmers and on State experiment station farms in North Carolina, South Carolina, and Georgia.

Work is in progress on machinery and methods of applying concentrated and ordinary commercial fertilizers at two locations in South Carolina, in cooperation with the South Carolina Experiment Station and the National Fertilizer Association. A large number of fertilizer distributors of varying designs are used to apply the fertilizer, and records are made as to the effect of the fertilizer applied differently on the germination of cottonseed and on the yield of cotton. No results are available, since this work was not started until the spring of 1929.

SOIL CHEMISTRY AND PHYSICS INVESTIGATIONS

This division is charged with a service duty which consists of the making of routine chemical and mechanical examination of soils for the Soil Survey and other units of the Government and of assisting in making adequate reply to private inquiries. This type of work has required the full time of five men and has resulted in approximately 500 chemical and 700 physical examinations of soils the results of which have been utilized by the Soil Survey, and in the development of the soil-erosion program. Information has also been furnished to the Bureau of Public Roads, the Bureau of Plant Industry, the Forest Service, and the Bureau of Entomology and to the Divisions of Soil Fertility and Fertilizer and Fixed Nitrogen Research.

In addition to this routine service the division has in progress researches on the following topics: The mineral and colloidal constituents of soil horizons in different soil types; the constancy of composition of the colloids within a soil series; the differences in composition of the colloids of different soil categories; the causes of toxicity of submerged soils; the absorption of acid dyes by soil colloids; the effect of colloid material on phosphorus assimilation by plants; the optical properties of soil colloids; the properties of soils which influence soil erosion; the use of the supersonic oscillator in the dispersion of soil particles; and the comparison of the physical and chemical characteristics of peat of widely different origin.

The investigations on improved methods of mechanical analysis of soils, which have been in progress for some years in connection with the routine work, will be published in a bulletin in the near future. The work has been completed and the manuscript is in preparation. There is very great need of increasing the scope of the work in the division, especially that on peat and organic soil colloids and investigations designed to utilize our present knowledge of soil colloids for soil amendment.

The work on certain of these projects is nearing completion; and when men are available work will be undertaken on a field method for determining the rates of percolation of water through soils, methods for diagnosing soil ills and prescribing remedies, the synthesis of soil components, and a study of the organic colloids of soils. During the year a number of subprojects have been terminated, and the results are now published or are in manuscript form awaiting publication. In the study of the occurrence of manganese dioxide in the soil there has been developed a method for the detection and estimation of this substance in soils. It has been shown that the dioxide of manganese does not exist in the colloidal fraction, but is formed through the agency of calcium carbonate, and that the presence of manganese dioxide is characteristic of certain soil series.

A chemical and mineralogical investigation of the alteration of mica in the soil has shown that mica may assume kaolinitic composition without visible alteration of its physical characteristics. This fact represents a very distinct contribution to our knowledge of soil genesis and evolution. A research completed during the year on the subject of the influence of different exchange bases on the properties of soil colloids has thrown important light upon behavior of colloids and has served to emphasize the relation between the properties of the finer soil constituents and the silica-sesquioxide ratio. A study of soil consistence has been undertaken by one of the field men of the Soil Survey, with a view to developing methods for estimating and terms for describing this important soil characteristic, for use in the field. This latter research, together with a number of other subprojects, is approaching completion, but the stage has not yet been reached which would justify prediction as to the probable date of termination.

SOIL MICROBIOLOGICAL INVESTIGATIONS

The inclusion of soil microbiological investigations in the Bureau of Chemistry and Soils has made possible the undertaking of a comprehensive study of the soil population, including the larger organisms such as fungi and molds as well as such microscopic forms as bacteria.

Specific studies of soil fungi in the laboratory have been undertaken in cooperation with the bacteriologists of the division in the studies of various soils under controlled conditions in which the isolation and identification of fungi are merely one part of a combined study of the population. In this way hundreds of plates have been reviewed and the influence of various treatments upon the soil observed. The results thus far harmonize with our previous opinion, that while very great numbers of species are found in culture, comparatively few of them have contributory significance. In green-manuring experiments carried at the 5-inch level under very nearly optimum moisture conditions practically no mold activity is reported. An increased mold activity is anticipated in subsequent experiments which are planned to be carried out at less than optimum moisture content.

Another line of work under this project has consisted of the study of collections of soil fungi submitted for identification or verification by others. In July, 1928, the Zaleski collection of 35 new species of Penicillium isolated from forest soils in Poland was received. These had already been studied and their descriptions published by Zaleski, who did not have, however, a sufficiently wide acquaintance with either Penicillia or with soil fungi to express an adequate critical judgment upon either the organisms or their significance. Each of those species has been repeatedly cultivated and fitted as nearly as possible into the scheme of classification which was being developed here. Another series of fungi from the soil was received from workers at Northwestern University, in Illinois. These have likewise been identified and fitted into the culture collection. Isaac N. Lewis, of the University of Texas, submitted another series of 22 species isolated from soils in different parts of the State of Texas, for identification in connection with his own studies of soil flora.

The constant occurrence in the soil of all kinds of saprophytic molds and some parasites makes significant the study of miscellaneous collections submitted by workers in different parts of the world for general identification purposes. The most complete collection which has been submitted to us this year is a group of Penicillia used by Harold Raistrick and J. H. Birkinshaw for biochemical studies at Nobel's Explosives Co. (Ltd.), Stevenston, Ayrshire, Scotland. Since these organisms have been made the basis of extensive biochemical investigations over a period of years, we have been asked to complete the identification to give definite value to these biochemical findings. That identification work is still in progress. In addition to a number of groups of cultures of minor importance which have been submitted for identification, we have been asked to identify a number of molds isolated from cases of human disease. There has appeared to be no place in the service to which these could be sent for identification except here. As cooperative work with the Public Health Service and the Bureau of Mines, a number of such cultures have been handled. The most important of them consisted of a series of Aspergilli found in lung cases by the Bureau of Mines. The identification and experimental work in that connection is still in progress.

The monograph of the genus Penicillium which was begun by Charles Thom in the cheese investigations of the Bureau of Animal Industry in 1905 and has been written intermittently in connection with the various other projects was completed and delivered to the publisher on July 2. It is understood that it will be published as a book and that its publication will be accomplished within the next three months.

Crop rotations on the miniature farm on Walker Hill, Arlington farm, which were started in 1914 by F. Löhnis, have been continued without change during the past year. Two rotations are used—one a continuous-cultivation 4-year rotation, the other an 8-year rotation with two years grass. Treatment of the various plots includes rotted stable manure, sodium nitrate, ammonium sulphate, green manuring with rye or rye and vetch, returning of plant residues with and without addition of artificial nitrogen following. Lime is added to keep soils neutral.

The object of these rotations is (1) to furnish various conditions of soil and of crop growth to serve as a basis for bacteriological studies, (2) to test the efficiency of green manures, artificial nitrogen, and rotted manure, with and without crop residues, in maintaining the nitrogen of the soil, and (3) to compare a continuous-cultivation rotation with one having two years of grass.

On account of the pressure of other work, no bacteriological work was done on these rotations. However, the weights of all crops were obtained and nitrogen analyses made in order to have a complete record of the crops and the nitrogen removed from the soil. Likewise account was taken of the nitrogen added. Studies on the decomposition of green manures in soils of various reactions were continued along the same lines as last year. Rye and vetch growing on Collington fine sandy loam and on Leonardtown clay loam were cut, weighed, and turned under 5 inches below the surface. Examination of samples from these plots taken at frequent intervals confirms the findings of previously reported work to the effect that the addition of the green manures had no effect upon the fungi and actinomyces. After the addition of the green manure there was a rapid decrease in nitrates, reaching a low level in from four to seven days, after which an increase in nitrates took place which reached the high level of the original soil at the last sampling at the end of a 63-day period. No change in the hydrogen-ion concentration was detected.

With the foregoing results obtained, it seemed advisable to make further study of additional factors involved in the decomposition of the green material, such as the determination of the evolution of carbon dioxide, the production of ammonia, the effect on the numbers of *Bacillus radiobacter* and on the numbers of protozoa.

Rye was grown on plots 9 and 10 and vetch on plots 11 and 12. Equivalent weights of rye and vetch grown on separate benches were added to plots 3 and 4 and plots 7 and 8, respectively. In addition, plots 3 to 12, inclusive, were treated with superphosphate and muriate of potash.

The total plate counts confirmed earlier findings, and the numbers of fungi in the soil treated with rye and vetch green manure grown elsewhere remained quite constant. However, on those plots where the rye and vetch were grown and turned under, the numbers were and remained double those on the other plots receiving the same amount of material which had been grown in the other greenhouse. There were some indications that the numbers of protozoa increased in the decomposing green material.

Although the number of *B. radiobacter* was high at the first sampling in the soils where rye and vetch were grown and turned under, the numbers increased approximately ten times after the turning under of the green manure. Where the rye and vetch were grown on separate plots and turned under, the numbers increased somewhat but not in proportion as they did when the rye and vetch were grown and turned under on the same soil.

Ammonia increased in the soil of the green-manured plots immediately after treatment. This indicates a rapid decomposition of the nitrogenous materials in the green manure and accounts for the subsequent rapid nitrification which took place under these conditions.

The hydrogen-ion concentration of the soils where rye and vetch were grown and turned under averaged about 0.3 to 0.4 pH higher than where the soils were manured with plants grown elsewhere. This was true of both the limed and unlimed soils.

The evolution of carbon dioxide increased within a few hours after the green material was turned under. The peak was reached in four days, after which there was a gradual decrease to the fourteenth day after treatment. Thereafter the evolution was quite constant although appreciably higher than in the control. Under these conditions it appears that there is a close correlation between numbers of microorganisms and the evolution of carbon dioxide.

From previous experiments it seemed advisable that an effort should be made to gain some insight into the localization of the activities taking place when the green manure was turned under. Accordingly two plots of Leonardtown clay loam, one limed and the other not limed, were treated with green vetch as in the other experiments. Samples were taken at the usual intervals. Each 6-inch core was divided into 2-inch layers representing 0 to 2 inch, 2 to 4 inch, and 4 to 6 inch depths. In addition, the green material itself was separated from the 4 to 6 inch layer as completely as possible. The corresponding segments of some 20 cores were composited and analyzed for total plate counts, *B. ra-*

diobacter, protozoa, ammonia, nitrates. and pH. Carbon dioxide evolution from the soil was also determined.

No noticeable increase in the plate counts occurred in the different layers of the soil itself. That is, the numbers in the 0 to 2 inch layer remained fairly constant as did those in the 2 to 4 inch and 4 to 6 inch layers. However, in the decomposing green material there was a tremendous increase in numbers. At the time of turning under the material the numbers were 400,000,000 per gram of green material and increased to approximately 10,000,000,000 per gram for the unlimed plot at the 4-day samplings.

On the plates made up to and including the seventh-day sampling there appeared many colonies resembling *B. radiobacter*. Isolations have been made and are being compared. Later samplings showed typical *B. radiobacter* in high numbers in the samples of decomposed material but practically none in the soil samples.

The numbers of protozoa remained low and constant in the soil. However, in the decomposing green manure the numbers increased, reaching the high point in four days. They decreased rapidly after the disappearance of the green manure. Nematodes were observed in considerable numbers in the early stages of the decomposition.

In the first 4 inches of soil no ammonia was present at any time. In the 4 to 6 inch layer no ammonia was present until the seventh day sampling, when 60 parts per million were observed. In the samples of decomposing green manure the highest amount, over 1,000 parts per million, occurred in two days. This dropped to 150 parts per million at four days.

There was an accumulation of nitrates in the 0 to 2 inch layer in both plots. In the other layers, 2 to 4, and 4 to 6 inches, the nitrates remained quite constant. In the green manure the original nitrate content was over 600 parts per million, which dropped to 30 parts per million in seven days.

The production of ammonia in the decomposing green manure noted above is reflected in a higher pH of this material. This change in pH occurred only in the green material and not in the surrounding soil.

Carbon dioxide evolution increased as in other experiments. In four days the maximum evolution occurred, decreasing thereafter until the fourteenth day, after which the amount remained fairly constant and considerably higher than in the control.

The results of the foregoing researches may be summarized as follows:

Under conditions of optimum moisture and temperature in the greenhouse the decomposition of green rye and green vetch is brought about largely by bacterial action. This activity seems to be localized in the decomposing material in both the limed and unlimed soils, since the numbers in the soil did not increase. In addition to the bacteria, the protozoa and nematodes increased in the decomposing material. The part they play has not been determined.

Rapid ammonification of the green manure was observed, which was followed by a rapid nitrification and an accumulation of nitrates in the surface 2 inches.

The pH of the decomposing green material was considerably higher than that of the surrounding soil, undoubtedly because of the formation of ammonia.

Active carbon dioxide evolution takes place during the first two weeks, which indicates that the carbohydrate material is converted into carbon dioxide.

In the studies upon the decomposition of green manures a new method of determining the evolution of carbon dioxide from soil was invented to overcome certain objections inherent in other methods, such as the passage of air through the soil, or the accumulation of excessive amounts of carbon dioxide over the soil, or the alteration of natural conditions by the use of vacuum or pressure. The method has the advantage of being simple, inexpensive, and efficient. This apparatus will be described in an article to be submitted later.

In cooperation with M. Phillips, studies on the decomposition of lignin by soil microorganisms have been undertaken.

Crude cultures of soil organisms were inoculated into nutrient media containing natural lignin substances. Also media containing purified lignin were prepared with and without certain substances, as sugar and cellulose. The results indicate that soil organisms decompose the lignin along with the cellulose when these are in natural combination; however, purified lignin seems to be very resistant even when accompanied by pure cellulose.

A joint paper giving the results of this work has been prepared and submitted for publication.

DISTRIBUTION OF LEGUME BACTERIA

By a continuance of a curtailment policy the free distribution of legume bacteria cultures has been limited to 10,000 bottles during the year. This is a decrease of 7,000 bottles, as compared with the number distributed during the similar preceding period. Much of the inoculating material distributed during the past fiscal year has been placed in the hands of county agents located in territories where the farm population needs encouragement in the growing of legumes. Some material has been distributed at the request of Senators and Representatives of various States and the remainder to those who in their applications to the department indicated a desire to do experimental work. A great many applicants have been furnished with information concerning sources from which cultures may be purchased.

EXAMINATION OF COMMERCIAL INOCULATING MATERIALS FOR PLANTS

From an examination of inoculating materials sold under 47 different names it is apparent that all but a few of those firms or institutions who handle the larger part of this business produce material of good quality. In the list of sources which is prepared annually for distribution to farmers and others, 31 of the brands of nodule bacteria cultures are represented. Information has been furnished to regulatory agencies and cooperative organizations with reference to the quality and merits of specific inoculating materials. It is apparent that some of this information has had a part at least in stopping the flow of certain questionable products either promoted in fact or as stock-selling propositions.

NODULE FORMATION IN RELATION TO CARBOHYDRATES

Samples of material collected in connection with the shading of soybean plants by cloth or corn have been partially analyzed; and while the figures obtained indicate some correlation, it is too early to draw definite conclusions. This experiment is being continued with more shading than was previously used, and results so far obtained give evidence that shading reduces the number of nodules. The results of experiments with inoculation on soybeans in the presence of sugars show that directly or indirectly certain of these carbohydrates, notably glucose, produce significant effects on nodulation and growth but apparently do not nearly take the place of sugars naturally found in the plant.

Work on the breeding of soybeans for susceptibility to nodule formation, which, by its nature will be of long duration but, on the other hand, requires but a small amount of time and labor, is being continued.

FERTILIZER AND FIXED-NITROGEN INVESTIGATIONS

F. G. COTTRELL, *Chief*

No problem of greater importance confronts American farmers than the maintenance of the fertility of their soils. With the increasing depletion of the fertility of North American soils by cropping and erosion, the problem of supplying better and more economical fertilizers becomes more vital to our national well-being. The chief aim of this unit is to assist the fertilizer industry and American farmers in devising methods for the most economical production and use of the raw materials—nitrogen, phosphoric acid, and potash..

This year, for the first time, nitrogen fixed within the United States is an important part of the total supply, and for the first time domestic production is going directly into fertilizer. Previously other markets were more attractive to the new industry. It is predicted that the air nitrogen output of United States plants for the current year will be three or four times as great as last year and will be equivalent to some 600,000 tons of Chilean nitrate of soda. For many years those interested in this matter have worked toward a common objective, or an industry comparable to the needs of the country. It seems now that the objective is within reach. In this remarkable advance the fertilizer and fixed-nitrogen unit has played an important part. Its work on phosphates and potash also has a direct and important bearing upon the farming and fertilizer industries.

This unit, by the very nature of its objective, is primarily a technical-research organization, with much activity that may be said to lie within the realm of pure science. Owing to this fact and to the strictly scientific nature of much of the present research of the unit, this report contains considerable material and phraseology that is somewhat technical.

CATALYTIC INVESTIGATIONS

Chemical industries of the present era and those looming largest on the horizon of the future will be dependent for their very existence upon effective and scientific use of catalytic materials. Accordingly, in the present program of work involving a study of catalytic materials and processes pertaining to the production and utilization of synthetic ammonia, every effort is being made to enable the contributions to be of use in leading to a better understanding of the phenomena of contact catalysis.

In studies of catalytic methods for purifying commercial hydrogen sufficiently to permit its being used in the production of synthetic ammonia, progress during the past year has been marked. It has been found possible to utilize hopcalite catalysts—such as were employed during the World War in gas masks—for the preferential combustion of the 1.5 to 2 per cent CO that remains in hydrogen obtained and purified in the water-gas process. An alternative method of effecting the nearly complete removal of the CO poison from hydrogen has been developed. It involves the use of fused cobalt catalysts promoted in such a way as to eliminate the formation of methane but catalyze the combination of steam and carbon monoxide. Equilibrium determinations in the system cobalt - cobalt oxide - steam - hydrogen have been completed.

The results will be of interest and use to all those utilizing the commercial water-gas process for production of hydrogen. An apparatus for continuous and automatic analysis of the effluent gases from catalyst test bombs for CO, NH_3, SO_2, etc., has been developed. A study of the two forms of Fe_2O_3, the cubic and rhombohedral modifications, has shown the incorrectness of the previously held view that the cubic modification was the more active catalytically. Some interesting characteristics of these materials have been discovered.

Continued effort is bringing to light valuable information relative to the commercial synthetic ammonia catalysts developed during the past 10 years at this laboratory. A quantitative study of the poisoning effects of these catalytic materials under high water-vapor pressure is in progress and is nearly completed. One more valuable link in the chain of experiments tending to show the reason for the difference in the behavior of good and poor synthetic ammonia catalysts will thereby be established. X-ray studies on the synthetic ammonia catalysts and the nitrides formed by interaction of the former with ammonia are being carried out. X rays have been shown to be without effect on the activity of a platinum catalyst used in the catalytic combination of hydrogen and oxygen. In all, eight papers relative to these catalytic processes and apparatus have been published or are in the hands of the publishers of scientific journals.

PHYSICS INVESTIGATIONS

As the commercial feasibility of a process depends upon the rate of a given chemical reaction, it is of utmost importance to have as complete an understanding as possible of the fundamental principles underlying chemical reactions and catalysis. This information is necessary for a better understanding of present nitrogen-fixation and fertilizer practices in order to suggest further improvements in these methods as well as to evolve new methods. An intensive study of the chemically active properties of atoms and molecules is being made by physical and radiation methods. In many cases these methods are the only ones available for obtaining the necessary information.

The function of a hot surface in the activation of nitrogen and hydrogen in the decomposition of ammonia was investigated by means of the Arrhenius equation. The relative effect of electrons and ions on the activation of nitrogen and hydrogen in the synthesis of ammonia has been determined. A study of ammonia synthesis in a glow discharge has resulted in the discovery of an electrochemical equivalence law in a gaseous discharge similar to Faraday's law for electrolysis, and a theory of the mechanism of the reaction has been advanced.

An X-ray laboratory with five separate installations has been equipped which permits of working with X radiations from 0.2 to 10 angstroms and taking all the standard types of X-ray photographs. Preliminary examinations of soil colloids have been made in cooperation with the Division of Soil Investigations. Diffraction photographs have been made in order to identify solid phases in the ammonia catalyst.

The mathematical work has resulted in the preparation of an electromagnetic chart correlating frequencies, wave length, and energy for radiation. The mathematical analysis of solid

fertilizers and the application of equations of state to gases and gaseous mixtures have also been made. The radiation equipment which is now being assembled consists of an infrared recording spectrometer operating from the visible to 2½ μ, a Steinheil spectrometer to be used in the visible, and specially designed quartz apparatus to be used in the ultra-violet. A cooperative program with the Smithsonian Institution has been inaugurated under which that institution will carry on the more theoretical aspects of the work and this laboratory will apply these principles and methods to nitrogen fixation and to agriculture.

HIGH-PRESSURE STUDIES

Ammonia, methanol, and certain other compounds are synthesized from gases at high pressures. At the pressures employed the physical properties of these gases can not be even approximately estimated by the laws governing the behavior of gases at moderate and low pressures. Engineering design of high-pressure apparatus and a complete understanding of the chemical equilibria involved in these syntheses depend upon accurate experimental data concerning such properties as compressibility, density, specific heat, heat conductivity, viscosity, vapor content of the gases in contact with liquids, and solubility of the gases in various liquids. Most urgent has been the demand for data on the compressibility of real gases. Earlier measurements on the compressibilities and densities of hydrogen, nitrogen, and mixtures of these gases at pressures from 100 to 1,000 atmospheres and temperatures from 0° to 400° C. have been supplemented by similar measurements at —25° and —70°. Pure carbon monoxide has been investigated at 9 temperatures, from —70° to 200°, and at 13 pressures between 25 and 1,000 atmospheres. Some preliminary work has been done on mixtures of nitrogen, hydrogen, and ammonia. The investigations on nitrogen and carbon monoxide have made available data for more accurate calculation of the specific heat of these gases. With a second complete high-pressure system recently installed, data are now being compiled on the solubility of hydrogen in water. In addition, as a necessary part of the general problem, a method has been devised for accurately determining the amount of inert gas in gas mixtures and for analyzing mixtures of carbon monoxide and hydrogen.

The corrosion tests on steel for ammonia synthesis, which have been under way for some time, will be finished within the next year. Laboratory tests on phosphoric acid corrosion of various concentrations of both purified and crude acid on irons, steels, brasses, bronzes, and metal alloys are in progress. This work is directly applicable to industry, and actual factory conditions are duplicated wherever possible.

TRANSFORMATION OF NITROGEN COMPOUNDS

In the study of the transformation of nitrogen compounds special emphasis has been placed on such compounds as may be obtained from the utilization of synthetic ammonia. Fundamental studies have been pursued involving the reactions occurring in the synthesis of urea, and a small-scale production plant has been operated. The conversion of urea into a compound of improved physical condition and of sufficient availability for fertilizer use has been investigated and additional progress made in the study of the oxidation of ammonia to nitric acid.

Urea as a compound very high in nitrogen has the advantage from the fertilizer standpoint of being readily soluble and available to the plant. Its value as a fertilizer material has been demonstrated both in this country and abroad, and extensive application probably would follow rapidly its commercial production in quantity. The synthesis of urea from ammonia and carbon dioxide has the commercial advantage of converting the ordinarily gaseous ammonia, produced by the synthetic ammonia process, into a readily soluble solid by combination with carbon dioxide, the principal by-product of the same process. Progress has been made in studying the phase relations of the melt obtained in converting ammonium carbamate to urea. Most of the analytical difficulties encountered have been overcome, and a method has been devised for measuring the vapor pressure of ammonia, carbon dioxide, and water in the gas phase. The data obtained from these studies will be of direct value in arriving at better operating conditions for the urea synthesis and for designing a proper still for the recovery of the unconverted portion of the gas. A redesigned small-scale urea plant has been operated successfully and has

demonstrated that the process can be carried out with little difficulty with a conversion of ammonia to urea so satisfactory as to encourage the prospect of the successful operation of the process commercially.

Efforts have been made to convert urea to a form less hygroscopic without impairing its usefulness as a fertilizer material. Urea readily forms addition products with various substances, one of which is formaldehyde. A study has been made of the properties of the urea-formaldehyde condensation products. The work has progressed sufficiently to show that some of the products obtained are considerably less hygroscopic than urea alone and have physical properties comparable with the more desirable fertilizer materials. The availability of the products has been tested by treatment with nitrifying bacteria and by determining the rate of nitrification. The results obtained give promise of varying the availability of the urea nitrogen as desired. This may be of considerable importance agronomically, as it is often desirable to have slowly available nitrogen in the soil, so that it may be gradually supplied to the crop during the growing season.

Investigation has been continued on the oxidation of ammonia as a source of nitric acid. A converter has been developed for the oxidation with pure oxygen, resulting in a high conversion of ammonia. By employing a converter so designed that there is a rapid removal of heat after the gas has passed the catalyst, high efficiency is obtained and safety of operation with the explosive mixture is successfully accomplished. The method provides for better economic operation through the more effective use of platinum and the recovery of the nitrogen oxides as strong acid. With the employment of cheap oxygen the process for producing strong acid would be considerably cheapened.

PHOSPHATES

The complete chemical composition of the principal commercial types and grades of phosphate rock produced in the United States, the mechanical composition of ground phosphate rock and the chemical composition of the various fractions separated therefrom, together with the relative colloidal material in phosphate rock, were determined. It is expected that these investigations will clear up many of the questions regarding the composition, constitution, properties, and origin of phosphate rock and point the way to a more rational utilization of the various types of rock for specific purposes, particularly as regards the direct use of the finely ground rock as a fertilizer.

The properties of representative samples of Florida soft phosphate and of the claylike phosphate found in abandoned ponds used to receive the waste materials from Florida hard rock phosphate washing plants was determined with a view to utilizing as fertilizers these materials, which contain up to 60 per cent of colloidal material. The relation between fluorine and the phosphoric acid content of all the commercial types and grades of phosphate rock produced in the United States was determined and results published. A general recovery of the fluorine in the manufacture of superphosphates would result in the production of compounds having a direct value of $3,000,000 annually.

An experimental blast furnace was operated in order to obtain fundamental data on phosphate smelting. The thermal efficiency of this furnace was tested and found to be about 70 per cent. Preliminary data obtained on slag melting gave indications of the proper mixture of slag and coke for operation in the furnace. Tests on the reduction of phosphate rock in the blast furnace have shown that the reduction of the charge does not take place until a temperature close to 1,450° C. is reached. Theoretical consideration of the reactions taking place in the furnace has been made. The results to date indicate the entire feasibility of the process. Improvements in both fuel requirements and recovery should follow with further studies.

POTASH

Although rapid progress is being made in establishing an American potash industry, the United States expends annually $18,000,000 for potash imported from Europe. The direct treatment of potash or phosphate-bearing raw materials with nitric oxide for the production of materials containing two or more essential plant foods is a problem of economic importance to producer and consumer. A large number of both potash and phosphate-bearing raw materials are suitable for this direct treatment, of which phosphate rock is the example chosen for experimentation. Results show that the phosphoric acid of phosphate

rock is easily rendered available by this method. Under properly controlled conditions a mixture of solid calcium nitrate and dicalcium phosphate is obtained which has many of the desirable physical and chemical characteristics of a good fertilizer. It was also found that by treating a concentrated solution obtained by passing water and nitric oxides in a countercurrent manner over phosphate rock with ground rock or other basic materials, a solid product is readily ob tained which is suitable for fertilizer purposes. This method of treating phosphate rock and other minerals containing fertilizer elements is apparently of real economic importance in that it offers a means of accomplishing simultaneously two essential operations—namely, the fixation of nitrogen oxides from ammonia oxidation as nitrates and the liberation of fertilizer elements present in an available form, which result in the direct formation in one operation of fertilizer compounds containing two or more plant-food elements.

Preliminary studies on the acid extraction of potash minerals for the recovery of various by-products to reduce the cost of the potash, as illustrated by past work with sulphuric acid on greensand, indicate the feasibility of this procedure. The principal acids are being applied to the principal potash minerals, emphasis in the recent past being placed on hydrofluoric acid in its action on Georgia shale and alunite. The success attending present endeavors to utilize blast-furnace design and technic in the volatilization of phosphorus from phosphate rock, combined with previous data established in the experimental volatilization of potash from its ores and economic analyses of proposed large-scale operations including by-product recoveries, strongly indicate the commercial feasibility of this procedure as another means of producing cheap potash, either alone or combined with phosphate. Enlarged equipment and greatly improved facilities have been installed for the more vigorous prosecution of this project now that increased funds have been made available for potash researches.

CONCENTRATED FERTILIZERS

The present importation of concentrated fertilizers from Germany and the growing demands for fertilizer with higher plant-food content make the concentrated-fertilizer investigations of prime importance. Within a few years the percentage of plant food in fertilizers should be doubled. On the basis of present freight rates this would mean an annual saving to the American farmer of $10,000,000 in freight and about $6,000,000 on sacks on the 8,000,000 tons of fertilizer consumed. Valuable contributions to the design of apparatus and methods of fertilizer analysis have been made during the past year.

The influence of relative and absolute humidities, temperatures, hygroscopicity, size, shape, homogeneity, and specific gravity of the particles and friction in relation to the drillability and application of fertilizers has been investigated. The fertilizer interests were so impressed with the results of this work that added funds were secured for experimental plot work. Studies on the prevention of the caking of fertilizers have been carried out by means of granulation of fertilizer materials by two methods—a nozzle spray and by means of centrifugal action on both the solution and molten material. Industry has taken these results, and it is now considered that the dehydration of fertilizer materials by centrifugal spraying is more economical than any other procedure. The relative hygroscopicity of mixtures of salts containing common ions has been determined. The results are being compiled for publication. The fertilizer manufacturers are now making use of the hygroscopicity data obtained from the bureau in compounding their fertilizer mixtures and are continually relying on it for information relative to new materials as they appear on the market.

Measurements are being made on the solubility of ammonium phosphate in water at different temperatures and of the same salt in varying concentrations of phosphoric acid. These results are indispensable in the successful operation of an industrial plant for the production of ammonium phosphate by the saturation process. Potassium ammonium phosphate has been prepared for the Soil Fertility Division for use in field tests. It has been found that the ease of preparation of this product increases with the grade of the potassium chloride. A study of its physical properties, including drillability, is also being made.

NITROGEN FIXATION BY LIVING ORGANISMS

The scope of the work dealing with the mechanism of nitrogen fixation by

lower organisms has been considerably broadened during the past year. Work has been conducted with legume nodule bacteria and their hosts, with Azotobacter, and with algae. Studies with chlorophyll have been included as a closely related subproject.

The research on legume nodule bacteria has furnished additional evidence to support the view that these bacteria can not fix nitrogen under ordinary laboratory conditions, when living apart from the host. Work is in progress now which it is hoped will furnish more definite information regarding the relations of these bacteria to the host plant. Morphological studies with the bacteria and the nodules have already suggested additional experiments of a chemical nature which will probably throw light on the mechanism of legume symbiosis.

A study of the gas metabolism of the free-living soil nitrogen-fixing bacterium, Azotobacter, has shown that this organism behaves uniquely toward oxygen gas concentrations, as compared with other living forms. At very low oxygen concentrations (0.1 per cent) they produce dry matter, i. e., grow at the expense of ten to fifteen times less food consumption as measured by total oxygen consumed than in air (21 per cent O_2), and at 80 per cent O_2 they do not make dry matter at all, although they still use relatively large quantities of food and oxygen. The most recent studies have shown that the various unique oxygen relations, of which one example has been given, are not the result of nitrogen fixation, however, since they obtain similarly when the organisms are fed fixed nitrogen, as ammonia. The actual experimental, as distinguished from the ideal thermodynamic, energy required for nitrogen fixation by Azotobacter has been determined with a fair degree of approximation. Work during the year has demonstrated that certain species of blue-green algae, living autotrophically, can fix atmospheric nitrogen. This type of alga is probably the first chlorophyll-containing organism which has ever been definitely proved to possess the ability to use free nitrogen gas. Certain investigators have claimed that a few higher plants can fix nitrogen, but their findings have not been generally accepted. Since the blue-green algae are widely distributed in soils, fresh water, and sea water, it is likely that they play an important part in adding to the fixed-nitrogen supply of the earth. These studies are being continued.

ORGANIC INVESTIGATIONS

An understanding of the chemistry and mechanism of nitrogen fixation in nature is being sought by a study of the properties of organic compounds which are present in nature and by attempts to use these compounds as reagents to fix nitrogen. Attempts will also be made to use such other reactive organic compounds as may have the capacity for combining with nitrogen. Included in this study will be a careful consideration of the properties of widely occurring and important compounds such as chlorophyll and related substances. During the past year efforts were directed toward developing the necessary laboratory technic for the preparation of organic free radicals and azo compounds, which are to be used in experiments planned to try to fix nitrogen by means of free radicals.

ENGINEERING DEVELOPMENT

The design of gas-tight apparatus in glass and metal for use at pressures from a very low vacuum to 15,000 pounds per inch is the basis of much of the work of this unit. The apparatus varied from sensitive radiation, ionization, and microapparatus to high-pressure relief valves, gauges, dead-weight gauges, and booster compressor.

INFORMATION SERVICE

A continuing demand for information, both technical and economic, on all phases of the work has been satisfied by conferences or correspondence with interested parties, and thus the results of research have been promptly placed at the service of the public. Muscle Shoals has continued to be a pressing problem in Congress and with the executive branch of the Government, and has been the subject of many inquiries. Every effort has been made to cooperate with other Government agencies in order to realize the highest efficiency in the public work.

PUBLICATIONS OF THE BUREAU OF CHEMISTRY AND SOILS ISSUED DURING THE YEAR JULY 1, 1928, TO JUNE 30, 1929

TECHNICAL BULLETINS

No. 80. Tests of Blowfly Baits and Repellents During 1926.
No. 94. Soil Reconnaissance of the Panama Canal Zone and Contiguous Territory.

CIRCULARS

No. 55. Soil Factors Influencing Crop Production in the Arkansas Valley, Colorado.
No. 56. Methods for Determining the Hydrogen-ion Concentration of Soils.
No. 61. A High-Pressure Gas-Compression System.
No. 64. Cyanamid, Its Uses as a Fertilizer Material.
No. 76. Fires in Cotton Gins and How to Prevent Them.

JOURNAL OF AGRICULTURAL RESEARCH ARTICLES

The Influence of Substituted Cations on the Properties of Soil Colloids.

SOIL SURVEYS

Harrison County, Iowa.
Jackson County, Minn.
Reconnaissance of West-Central Texas.
Moapa Valley Area, Nevada.
Ogemaw County, Mich.
Lycoming County, Pa.
Olmsted County, Minn.
Henderson County, Tex.
Auburn Area, Calif.
Chattahoochee County, Ga.
St. Marys County, Md.
Lake County, Ohio.
Cherokee County, Ala.
Green County, Wis.
Sheboygan County, Wis.
Fremont County, Iowa.
Harris County, Tex.
Harrison County, Miss.
Greene County, N. C.
Bishop Area, Calif.
Jones County, Iowa.
Macomb County, Mich.
Hillsdale County, Mich.
Minidoka Area, Idaho.
Worcester County, Md.
Rutherford County, N. C.
Lawrence County, Mo.
Cherokee County, Iowa.
Buffalo County, Nebr.
Walworth County, S. Dak.
Antrim County, Mich.
Isabella County, Mich.
Calhoun County, Ga.
Randolph County, Ga.
Lamar County, Ga.
Barry County, Mich.
Livingston County, Mich.
Berkshire County, Mass.
Garden County, Nebr.
Platte County, Nebr.

FARMERS BULLETIN

No. 1590. Fire-Protective Construction on the Farm.

MISCELLANEOUS

Analyses of Some English Bookbinding Leathers (joint publication of Government Printing Office and Department of Agriculture. Published and printed by the Government Printing Office.)

YEARBOOK ARTICLES

Nitrogen Loss from Soil by Leaching Is Largely Preventable.
Organic Materials May Hurt Crops if Applied Undecayed.
Lawn Grass Aided, Weeds Checked by Ammonium Sulphate.
Avocado Culls May Prove Source of Oil and Livestock Feed.
Soil Bacteria Useful to Farmers May be Caused to Multiply.
Belt Failure Often Caused by Neglect or Faulty Installation.
Soil Deterioration by Sheet Erosion Lowers Fertility of Vast Area.
Fire Risk in Country Grain Elevators Not Recognized Enough.
Food Spoilage, Which Causes Heavy Losses, Due to Many Causes.
Cake of Different Kinds Needs Flour of Different Kinds.
Canning of Vegetables by New Steam Process Holds Flavors Better.
Coloring of Mature Fruit by Ethylene Gas Unobjectionable.
Cod-liver Oil in Feeds Requires Care to Preserve Vitamin.
Food Colors Certified by the Department are Both Harmless and Pure.
Dust-Explosion Hazard Exists in Nearly all Manufacturing Plants.
Dyes Important Both in Diagnosis of Disease and as Medicinal Agents.
Fertilizer Known as Double Superphosphate Has Useful Properties.
Fertilizer Concentration Need Not Increase the Risk of Burning Plants.
Iodine Survey Planned in Studies of Minor Constituents of Food.
Harness Life Can Be Doubled or Trebled by Cleaning and Repairing.
Soil Particles That Glitter Are Often Mistaken for Gold.
Molds Pressed Into Service in Utilizing Some Farm Products.
Nitrogen Supply of United States Much Dependent on Imports.
Sugar Cane Requires Nitrogen As Chief Plant-Food Element.
Insecticide Residues Removed from Fruit by Various Washes.
Light Rays a Factor in Helping to Solve Many Farm Problems.
Insect Poison Called Rotenone Highly Toxic But Costly at Present.
Soil Survey in 25 Years Maps More Than Half Our Arable Land.
Urea Demonstrated to Be Valuable As Nitrogen Fertilizer.
Sweet Potatoes As Possible Source of Starch Investigated.
Peat Deposits Under Some Conditions Are Serious Fire Hazard.
Pecans Respond to Commercial Fertilizer When Rightly Applied.
Potash Production in United States Increasing Though Still Far Below Needs.
Insecticide Research Develops a Promising Substitute for Nicotine.

U. S. GOVERNMENT PRINTING OFFICE: 1929

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For release to morning papers of December 11, 1929

REPORT OF THE CHIEF OF THE BUREAU OF DAIRY INDUSTRY

United States Department of Agriculture,
Bureau of Dairy Industry,
Washington, D. C., August 26, 1929.

Sir: I have the honor to submit herewith a report of the work of the Bureau of Dairy Industry for the fiscal year ended June 30, 1929.

Respectfully,

O. E. Reed, *Chief of Bureau.*

Hon. Arthur M. Hyde,
Secretary of Agriculture.

The work of the Bureau of Dairy Industry was directed by L. A. Rogers, acting chief, from January 1 to September 1, 1928, when O. E. Reed was appointed chief, succeeding C. W. Larson.

During the past fiscal year the investigational work of the bureau was expanded, and changes in its organization were made. The western office at Salt Lake City, Utah, was closed on June 30. This office was established in 1912 for the purpose of aiding the Western States in a program of dairy development, and much good was accomplished. In recent years, however, because of the character of the work, most of it had been taken over by the extension forces of the State agricultural colleges.

This bureau has for many years made direct contact with the various State and local agencies in placing the results of research before the public. At the present time it is thought that this work can be most effectively carried out through the cooperation of the Bureau of Dairy Industry and the regular extension forces in the various States. Accordingly, we have joined hands with the office of cooperative extension work in a combined effort to assist all the States along the lines of dairy production and quality improvement. Subject matter specialists in dairying will be assigned to each of the four principal geographic divisions of the United States. They will work in cooperation with the directors of extension and dairy extension specialists in the respective divisions. This arrangement is designed to replace to a very large extent the work formerly conducted by the dairy-introduction project of the bureau.

The dairy-herd-improvement work has been given greater recognition and is now on a basis comparable with other major bureau projects. The work of dairy manufacturing and that involving the introduction of manufacturing methods into creameries and factories has also been placed on a major project basis. The investigational work of the dairy experiment farm at Beltsville, Md., dealing with the feeding and management of dairy cattle, has been placed under the supervision of the Division of Dairy-Cattle Breeding, Feeding, and Management.

During the past year the dairy work at the Sand-hill station in South Carolina was begun. A number of pure-bred Guernsey cattle have been purchased as a part of the foundation herd. This station was established for cooperative work with the South Carolina Agricultural Experiment Station in dairying, soil improvement, and crop production. Although three bureaus of the department are primarily interested in the station's work, this bureau is charged with the administration of the appropriations for its support. The Bureau of Plant Industry and the Bureau of Chemistry and Soils, through their offices of forage-crop and soil-fertility investigations, have made excellent progress in the soil-improvement and forage-crop production work.

A tract of land for the dairy experiment station near Lewisburg, Tenn., the establishment of which was provided for by the act of Congress ap-

proved May 29, 1928, was recently deeded to the Government. The tract embraces approximately 500 acres and was purchased by the State of Tennessee. A herd of purebred Jerseys will be established at this station. The building-construction work is now in progress, and the station should be placed in active operation by the spring of 1930.

DIVISION OF DAIRY-RESEARCH LABORATORIES

L. A. ROGERS, *Chief*

NUTRITION OF DAIRY COWS

In studying the relation of protein metabolism to milk secretion and growth of the animal, much attention has been given to synthesizing certain amino acids preparatory to feeding experiments with rats to determine whether it is necessary to furnish these amino acids in the diet. Valine and isoleucine have been prepared and progress made in the synthesis of glutathione.

In the investigations on a satisfactory ration for high-producing cows comparisons have been made of different grades of alfalfa and timothy hays. On timothy-hay rations in which the calcium-phosphorus ratio was kept at approximately 1 : 12 by feeding a grain mixture high in phosphorus and adding calcium chloride and calcium carbonate, cows were kept in positive calcium balance for 12 weeks. Cows fed for three lactation periods on alfalfa hay and grain have gone off feed in a way which indicates a deficiency in the ration. This was corrected by the addition of timothy hay.

New work has been undertaken on the importance of vitamins in the feed of cows. A rat colony has been established and preliminary work done on the possibility of maintaining normal growth and reproduction on cow rations. Work has been started on the relative vitamin A content of different grades of alfalfa and timothy hay.

BACTERIOLOGY AND CHEMISTRY OF MILK

Further work on the action of bacteria on the proteins of milk indicates that the division of bacteria into proteolytic and nonproteolytic groups is more or less arbitrary, since bacteria classed as nonproteolytic reduce the quantity of casein nitrogen to some extent. Certain distinctions may be drawn, however, for purposes of classification on the basis of quantitative differences.

Further results have been obtained from studies on the factors which control the rate of growth of bacteria. In obtaining the usual growth curve the final population is restricted by the experimental conditions, and the maximum number is followed by a sharp decline. It has been shown that growth in broth held in a long tube does not progress at a uniform rate but by alternating periods of slow and rapid advance. When a colony is maintained in broth under conditions which permit a continuous flow of fresh medium through a flask, a fairly constant population is maintained indefinitely. This investigation has also shown that the ordinary streptococci of sour milk have certain effects on other bacteria which can not be ascribed to the action of the acid reaction which they produce. *Streptococcus lactis* changes fluid media so that the initial growth is accelerated but the final population is limited. It does not accelerate the growth of bacteria of the *Esrichia coli* type, but has a distinct inhibiting effect.

The electrometric determination of the reduction potential produced in milk by the simultaneous growth of more than one species of bacteria shows that the characteristic potential of one of these species prevails. *S. lactis* is one of the species in which the influence of reduction potential usually overshadows that of any other organism present.

New indicators, which on preliminary experiments gave some promise of having advantages over methylene blue as an indicator of reduction potential, have proved unsatisfactory on more extended trial.

A test for the heat stability of milk has been devised and is now being tried under commercial conditions. This does not detect all lots of unsuitable milk, but almost without exception samples reacting to the test prove to have a low coagulating point. In 72 per cent of 25 experiments the time of coagulation of evaporated milk was materially increased by eliminating lots of milk which reacted to the test.

Measurements of the amounts of acid which a milk will absorb without changing its hydrogen-ion concentration have given some valuable information on the probable constitution of milk and its reactions under manufacturing conditions.

Milks from different breeds of cows vary markedly in their buffer action. The influence of this characteristic in cheese making is evidently of considerable importance. The buffer value of milk modified for infant feed-

ing is of especial importance on account of its relation to the nature of the curd formed when it is precipitated. Investigations made in these laboratories have indicated that albumin may be of special importance in this connection, and a possible outlet for lactal bumin is suggested.

EVAPORATED MILK AND DRIED SKIM MILK

It is well known that milk as it is secreted varies in its stability to heat. Work has been under way for several months on variation in this property of milk from individual cows over an entire lactation period. Determinations of the composition of the milk and its reactions to various tests which give indications of its physical properties have been made at stated intervals and the results correlated with the stability of the milk after evaporation. The variations in any one constituent or reaction furnish no evidence of a direct correlation with the heat stability of the evaporated milk.

It is sometimes observed that under factory conditions milk has a low heat stability and that this is correlated with the presence of certain types of bacteria. It has not been possible, however, to reproduce these conditions in the laboratory with pure cultures. Recent results have indicated that the reason for this is that the bacteria in question grow only rapidly enough to affect the milk when they are associated with certain other types of bacteria.

A set of color standards through which the hue, brilliance, and chroma of evaporated milk can be determined has been devised. By means of these standards the influence of various factors on the color of evaporated milk has been measured. The rate of the formation of color with increasing temperature or time of sterilization is of a catalytic nature. This work has also shown that the change in color of evaporated milk in storage is in the chroma and progresses at a much faster rate at the higher temperatures of storage.

In connection with the investigations on the keeping quality of dairy products, especially dried skim milk, a photochemical method for determining the resistance of fats to oxidation has been perfected. Its use will make possible the accurate determination of keeping quality. In connection with the work on the use of dried skim milk in bread making it has been necessary to ascertain the effect of the bleaching process on the action of the dried milk on volume and texture of the loaf. In general the milk did not improve the loaf made from unbleached flours, and the effect on the bleached flours varied slightly with the bleaching process used. Incidentally a simpler, much quicker, and possibly more accurate method than the one ordinarily used has been developed for determining the hydrogen-ion concentration of flours.

ICE CREAM

Much attention during the past year has been given to the effect of ingredients and methods of manufacture on the physical properties of the mix. This has included investigations showing that the addition of gelatin to an ice-cream mix converts it from a product having only very slight plastic properties to one markedly plastic. This effect varies with the quality of the gelatin. Unless a very poor grade of gelatin is incorporated a mix with gelatin exhibits a higher basic viscosity than a similar mix without gelatin. Incidentally this work has provided a method for standardizing the usual empirical method for measuring gel strength.

It is evident from the results obtained that the setting of the gelatin during ripening is not influential in affecting the quality of the finished product. It seems probable that aging influences the crystallization process in the freezer and that the surface adsorption of gelatin by the solid particles of the mix may be a significant factor in the aging process.

Work on the effect of forewarming temperatures in making dried skim milk indicates that the higher temperatures produce the most satisfactory dried milk for ice-cream making. In some comparisons of different grades of honey for sweetening and flavoring ice cream, the results show that the majority of consumers do not care for the honey flavor except in those lots in which the finest grades of honey were used.

CHEESE

It has been found that in 10 to 15 per cent of the cheese made under factory conditions the use of pure culture starters and clarification fail to overcome defects due to abnormal gas fermentations. There is also a tendency, especially in the culture cheese, to a dry woody texture which detracts from the value of the cheese. Recent investigations have shown that cultures which develop acid rapidly have a tendency to produce a poorer texture than those which form acid more slowly. The superior texture does not

depend on proteolysis but is probably connected with the state of combination of the water in the cheese.

In suppressing abnormal gas formation, the cheese maker is dependent on acid-forming cultures which can survive the high-cooking temperatures of the kettle and begin to grow in the hot curd before the gas formers become established. A new culture has been found which meets these requirements perfectly. It grows over an exceptionally wide range of temperature, including that of the Swiss-making process. Consequently it is growing actively when the curd is put in the press and the temperature is still too high to permit the development of the bacteria producing the pressler type of abnormal cheese. The development of acid begins very promptly. In combination with the two cultures already in use this culture has never failed to suppress abnormal gassy fermentations both under laboratory and factory conditions. Apparently it has no detrimental effect on the texture.

In the course of this work it was found that the milks of different breeds varied markedly in their reactions to the manufacturing process. A milk which would be uniform from day to day was therefore obtained by mixing different quantities of Holstein and Jersey milk.

One of the most serious obstacles in the production of cheese of high quality is the difficulty of marketing it in a form which will enable the consumer to recognize and select the brand suited to his taste. An attempt has been made to devise some method by which Roquefort, Cheddar, and Swiss cheese could be marketed in convenient forms without destroying their characteristic appearance and flavor. The methods tried have included wrapping and coating prints to prevent molding and canning both prints and Cheddar cheese pressed in a hoop to fit the can. The trouble from swelling due to the formation of gas in the normal ripening has been overcome, and results obtained in preventing molding have been sufficiently promising to warrant a small commercial experiment at the Grove City creamery.

BY-PRODUCTS

A method previously developed in this laboratory for making a soluble lactalbumin from whey was applicable only to low-acid wheys such as those obtained from Swiss cheese. This method has been modified to make it workable with acid wheys and at the same time to reduce the ash content of the dried product about 25 per cent. Even with this improvement the ash content is too high for some possible applications of the whey powder, and work is in progress on methods of reducing it without affecting the solubility of the albumin. A method has been found which, under laboratory conditions, removes 60 per cent of the ash.

In order that new uses for milk sugar may be developed it is necessary to have more information in regard to its physical properties when used both alone and in various combinations with other sugars. It has been found that while saturated solutions of cane sugar begin to take up water at a relative humidity of 77.4 per cent, lactose does not absorb moisture until the relative humidity reaches 93 per cent.

With the increasing interest in the therapeutic aspects of milk sugar a relatively large quantity of it is now used for direct human consumption. The desirability of the usual alpha form for this purpose is lessened by its low solubility and lack of sweetness. A method has been perfected for factory conditions by which the sweeter and more soluble beta form may be made at very little or no increase in cost. This method has been adopted by a nationally known food company which is prepared to sell this sugar on a large scale.

The concentrated sour skim milk now made quite extensively as a poultry feed is also a valuable source of milk solids in baked products. Because of high acidity of the concentrated sour skim milk it is necessary to modify the usual proportions of some of the ingredients, and recipes have been prepared for various types of baked products in which the sour skim milk is used as the source of milk solids.

One of the important means of converting skim milk into human food is by the manufacture of cultured buttermilk. The control of the viscosity and stability of this product is important, and some of the principal factors controlling these characteristics have been determined.

DIVISION OF DAIRY-CATTLE BREEDING, FEEDING, AND MANAGEMENT INVESTIGATIONS

R. R. GRAVES, *Chief*

THE BELTSVILLE EXPERIMENTAL BREEDING HERD

PROGRESS OF THE LINE BREEDING-OUTBREEDING PROJECT

Denton Colantha Sir Rag Apple, the first proved outbred sire used in this

project, had a total of 37 daughters, of which 32 were still in the herd at the beginning of the year. One became a nonbreeder and another died, leaving 30 of his daughters still alive with only 1 under breeding age. Of the 41 foundation cows only 19 left female progeny in this first generation, and at present the 30 living daughters of Denton represent only 17 of the foundation cows. Twelve of these 17 have living female descendents in the second outbred generation.

To produce the second outbred generation, the daughters of Denton Colantha Sir Rag Apple are mated to the second proved outbred sire, Varsity Derby Matador. This year he sired 8 calves, of which 6 were males. The 2 females raised the total of the second generation outbred females to 21, of which 16 have reached breeding age. The high percentage of males in this group was rather unusual; but there is reasonable assurance of a sufficient number of females to carry on the work successfully, as 8 cows and heifers are pregnant to the service of Varsity Derby Matador, and he is still a sure breeder at the age of 11 years. He also has 1 first-generation outbred daughter from 1 of the 2 foundation cows still in the herd.

The third outbred proved sire, Pride of the Bess Burkes, is being mated to the daughters of Varsity Derby Matador. He now has three daughters in the herd, and six cows are pregnant to his service.

The first linebred generation of this project is being produced by mating Sir Gerben Colantha Rube, a son of Varsity Derby Matador from a daughter of Denton Colantha Sir Rag Apple, to the daughters of Denton. According to the plan, these daughters are first mated to Varsity Derby Matador for the outcross; and after dropping an outbred heifer they are then mated to Sir Gerben Colantha Rube. (This mating is of the relationship of nephew to aunt.) He now has three linebred daughters, and nine cows are pregnant to his service. When his daughters are old enough to breed they will be mated to their own sire, for a closely inbred generation, before continuing line breeding to the next sire.

The breeding efficiency of the Holstein herd in this project continued good. Out of 41 females old enough to calve, 32 pregnancies occurred, resulting in 9 female calves, 16 male calves, and 7 abortions. Last year 15 females and 12 males were born. Twenty-eight of 50 females of breeding age are pregnant. The total number of females at the beginning of the year was 59, of which 5 died or were killed. One of the nine heifer calves died, which makes the total number of females now 62.

PROGRESS OF THE INBREEDING-OUTBREEDING PROJECT

Three sires used in this project have now become unserviceable. The Moose O'Fernwood's death was reported last year, and a proved bull of similar breeding has been obtained to take his place. Tiddledywink's Raleigh, another sire in this project, was slaughtered when the results of injuries caused him to become infertile. Sophie Torono 23d, while still alive, is no longer fertile.

Oxford May's Interested Owl, a bull of similar breeding to the Moose, was brought in to succeed him. His first six tested daughters all qualified for silver medals. He came to Beltsville on December 1, 1928, and is being mated to foundation cows, daughters of the Moose O'Fernwood, Sophie's Torono 23d, and Tiddledywink's Raleigh. Fifteen cows and heifers are pregnant to his service.

The inbreeding work in the Moose O'Fernwood group was carried forward by mating his daughters to a 75 per cent inbred son. There are now four inbred daughters by this sire, and five cows are pregnant to his service.

In the group headed by Sophie's Torono 23d one additional outbred heifer was born, bringing his total living outbred daughters to 17. One inbred female was dropped but died at birth, and he now has five 75 per cent inbred daughters.

Tiddledywink's Raleigh now has 10 outbred daughters and 1 inbred daughter in the herd.

A year ago attention was called to the high rate of calf mortality among the inbreds, as 8 of 16 males and 5 of 10 females had died under 1 year of age. Since many of the deaths resulted directly or indirectly from digestive disturbances, the method of feeding young calves was changed, the quantity of milk fed being reduced and no silage given to calves under 60 days old. During the year just closed 8 male and 8 female inbred calves were born, and only 1 of each sex has died under the new system of feeding.

THE FAMILY-CROSSING PROJECT

Although only three of the original foundation females of this family-crossing project remain in the herd, there are now animals of both sexes

in the four 2-family groups, which insures the representation of the eight original families in the future breeding work of this project. At present there are six 2-family females and eleven 2-family males; 11 females and 7 males have 4 distinct families in their immediate ancestry, and 2 females and 1 male are in the 6-family group.

From 59 of the 69 Jersey females old enough to calve, there were 22 female calves, 23 male calves, 7 calves born dead, and 12 abortions. Of 82 females of breeding age, 45 are pregnant. There were 92 females in the herd at the beginning of the year, 10 of which died or were slaughtered. Three of the 22 female calves died, bringing the total to 101.

OFFICIAL TESTING AND PHOTOGRAPHY

In accordance with the plan of giving each female in the breeding project an official production record at 2 years of age and again at maturity, preferably at 5 or 6 years of age, 29 additional records were completed during the year. An effort is made in this test work to keep the environmental conditions as nearly uniform as possible from year to year. The animals are milked three times a day throughout the year, are kept in box stalls, and receive the same kinds of feed during the entire year. The quantity of feed consumed by each animal is carefully recorded. The production records thus made are considered as the measure of the maximum capacity of the animals under these conditions and are used in the breeding studies as an indication of inheritance for milk and butterfat production.

Thirteen Holstein and 16 Jersey cows completed official milk and butterfat tests during the year. Seven mature Holsteins averaged 18,070 pounds of milk and 638 pounds of butterfat, three 3-year-olds averaged 13,802 pounds of milk and 470 pounds of butterfat, and three 2-year-olds averaged 15,846 pounds of milk and 553 pounds of butterfat. The average for the 13 records was 16,572 pounds of milk and 588 pounds of butterfat. The average per cent of butterfat for these 13 tests was 3.55. Of the 16 Jerseys, 3 mature cows averaged 10,629 pounds of milk and 592 pounds of butterfat, four 3-year-olds averaged 10,231 pounds of milk and 548 pounds of butterfat, and nine 2-year-olds averaged 9,722 pounds of milk and 528 pounds of butterfat, a total average of 10,021 pounds of milk and 545 pounds of butterfat.

A summary of all official records made at Beltsville shows that 81 Jerseys have completed 105 records, which average 9,832 pounds of milk and 538 pounds of butterfat, the average age at which the records were made being 3 years 9 months. Sixty-three Holsteins have completed 94 official records averaging 16,488 pounds of milk and 569 pounds of butterfat at an average age of 3 years 11 months.

The regular schedule of photographing animals in the breeding herds at Beltsville was continued, and 319 pictures were taken, the increase over last year being due to the greater size of the herd. This work has now progressed to a point where photographs are available for the grouping of the pictures of the daughters of various sires in use in the experimental herds, together with the pictures of the dams of these daughters. Such photographic charts, showing as they do several generations of animals with production records, are of great value to the student of cattle breeding.

PROVING BULLS

During the past year the status of the bull-proving work at Beltsville was greatly improved by eliminating several of the oldest bulls and by dropping those cooperators who were not keeping satisfactory records. Information on all bulls in the process of being proved is now being gathered at regular intervals and kept in tabular form in the office.

Forty-eight Holstein bulls are now in service in cooperators' herds in the vicinity of Beltsville, 14 are contracted for, and 6 are being lent to colleges, making a total of 68. Thirty Jersey bulls are in cooperators' herds, 8 are contracted for, and 6 are in college herds, a total of 44, making 112 bulls of both breeds. To avoid inbreeding it is necessary to move the bulls from one herd to another after about three years. Seven bulls were exchanged among cooperators, and 15 other bulls were placed with new cooperators. With the additional bulls contracted for, a total of 47 new cooperators were added to the list during the year. Sufficient information was obtained to afford a good estimate of the transmitting ability of six bulls.

Some idea of the scope of this work is given by the following figures: Holstein bulls owned by this bureau now

have 650 daughters in the herds of co-operators. Of these, 169 are in milk, 258 are yearlings, and 223 are under 1 year of age. The total number of daughters of Jersey bulls is 251, of which 35 are in milk, 67 are yearlings, and 149 are under 1 year of age.

The bureau is also proving the most promising privately owned young sires of the various breeds by comparing the records of the daughters and the dams of the daughters. The records of the daughters of about 3,000 sires are current in the files of the bureau most of the time.

HEALTH OF THE HERD AND FERTILITY STUDIES

During the past year 12 females in the abortion-free herd became positive to the agglutination test for abortion disease and were added to the abortion-infected herd. Since May, 1926, when most of the abortion-infected animals were moved to new quarters, 43 animals have been taken from the abortion-free herd because their serum had changed from negative to positive when the agglutination test was applied. Seventeen of these have changed since October, 1926, when a complete separation was made. The abortion-infected herd now consists of 78 females, all of breeding age; and the abortion-free herd consists of 160 females, 112 being of breeding age.

The number of animals of each breed in the two herds are shown in Table 1.

TABLE 1.—*Condition of Beltsville (Md.) animals in respect to abortion*

Breed	Number in abortion-free herd of—		Number in abortion-infected herd	Total
	Breeding age	Calves		
Grade	23	13	13	49
Holstein	45	14	16	75
Jersey	44	21	49	114
Total	112	48	78	238

The animals are tested for abortion disease every 60 days in an effort to curtail the losses from the abortion-free herd. The milk from the abortion-free herd is also examined for *Bacillus abortus*. The bacteriological and pathological work in connection with abortion disease is being carried on by the Bureau of Animal Industry.

The breeding efficiency of the animals in these two herds may be shown in two ways: (1) By the percentage of animals of breeding age that became pregnant during the year; and (2) by the percentage of animals actually bred that became pregnant during the year. According to the first method, the abortion-infected herd, with 57 pregnancies out of a total of 89 animals, had an average breeding efficiency of 64 per cent. The abortion-free herd, with 80 pregnancies out of a total of 125 animals, had an average breeding efficiency of 64 per cent. According to the second method, the abortion-infected herd, with 57 pregnancies out of a total of 69 animals, had an average breeding efficiency of 82.60 per cent. The abortion-free herd, with 80 pregnancies out of a total of 103 animals, had an average breeding efficiency of 77.66 per cent.

FEED CONSUMPTION AND MILK PRODUCTION

The records of cows in the breeding herds of the bureau are made under carefully controlled conditions in order that the animals of different generations may have equal opportunity to demonstrate their producing capacity. A careful record of feed consumption, therefore, is kept throughout the year during which the animal is on test. About 200 records of feed consumption and production, available at the present time, furnish valuable data for studying the influence of such factors as size of animal, amount of production and economy of production, and the limitations of feed-consuming capacity.

Table 2 shows the relation between size of cow and the quantity and economy of milk and butterfat production. In some of the weight groups there were too few animals to make the results indicative. With the exception of the 2-year-old Holsteins, however, the table shows that as the weight of the cows increase there appears to be an increase in quantity of production. The animals when on test were allowed approximately 10 per cent more nutrients than their requirements for maintenance and milk production. The reason for the greater economy of the higher producers, therefore, may be that because of the necessity of greater feed consumption to take care of their increased production they ate less of the 10 per cent surplus nutrients than did the lower producers.

TABLE 2.—*Relation of size of cow to quantity and economy of production*

Breed	Range in weight	Cows	Production		Total digestible nutrients over maintenance per—	
			Milk	Butterfat	1,000 pounds milk	100 pounds butterfat
Jersey:	*Pounds*	*Number*	*Pounds*	*Pounds*	*Pounds*	*Pounds*
2-year olds	651–775	2	8,300	462.1	591.5	1,062.4
	776–900	23	8,973	488.4	578.5	1,056.9
	901–1,025	12	8,951	490.1	571.7	1,018.8
Mature cows	761–885	2	11,258	562.9	490.0	999.5
	886–1,010	14	11,409	595.8	507.4	983.3
	1,011–1,135	12	11,252	630.9	511.9	913.5
	1,136–1,260	2	10,782	605.0	489.7	872.8
Holstein:						
2-year olds	951–1,110	11	14,475	501.2	404.2	1,166.4
	1,111–1,270	21	14,190	490.8	391.4	1,130.1
	1,271–1,430	6	14,370	487.4	396.9	1,160.1
Mature cows	1,141–1,270	8	16,788	567.0	380.3	1,123.0
	1,271–1,400	11	18,122	654.8	376.9	1,040.4
	1,400–1,530	9	20,091	712.3	383.0	1,085.7

A STUDY OF THE RELATION OF THE CONFORMATION AND ANATOMY OF THE DAIRY COW TO HER MILK AND BUTTERFAT PRODUCING CAPACITY

The plan of slaughtering cows of known producing ability to determine the relationship between their external form and their internal anatomy and between both their external form and internal anatomy and capacity for production has been continued. This work is carried on not only at Beltsville, Md., but also in cooperation with a number of the State experiment stations. The University of Wisconsin, the University of Florida, and Michigan State College have been added to the list of cooperators during the year. The work is already under way at Wisconsin and Florida and will be introduced at Michigan in the near future. The Kansas, Missouri, Iowa, Wisconsin, Cornell, Geneva, and Pennsylvania stations have been visited during the year for the purpose of assisting in carrying on and coordinating the work. Ante-mortem and post-mortem reports on 44 cows with production records have been obtained during the year. Ten of these reports were prepared at Beltsville; 18 at Pennsylvania State College; 4 at the University of Florida; 3 at the University of Missouri; 2 each at the University of Alabama, Kansas State Agricultural College, Clemson College, S. C., and the University of Wisconsin; and 1 at the Iowa State College. The total number of such ante-mortem and post-mortem reports now on file is 231. Seventy of these have been prepared at Beltsville, 66 at the Pennsylvania State College, 40 at Cornell University, 12 at the University of Missouri, 9 at Clemson College, S. C., and 5 or less from each of the 11 other cooperating stations. In addition to those enumerated, ante-mortem and post-mortem reports for five bulls have been prepared at Beltsville. Measuring instruments have been distributed to each of the newly added cooperating stations.

MAMMARY-GLAND STUDIES

For several years the udders of all females in the breeding herd at Beltsville have been examined at regular and frequent intervals from birth to 18 months of age and periodically through the first lactation period and at least one other lactation period after maturity. Individual variations in internal and external udder development at any age and changes which occur during the productive life of the cow are recorded. During the year 260 such examinations have been made on growing heifers and 482 on lactating cows. The examinations of lactating udders are supplemented by photographs taken in the third month of the lactation period.

When a cow in the Beltsville, Md., herd is slaughtered her udder is removed, filled with fluid, frozen, and cut into sections. Photographs of each section are obtained; and thus a permanent record of the structure of the gland is available for study in connection with records of development, changes during lactation, and performance. Fourteen udders of heifers and cows have been sectioned during the year. Studies to determine the capacity of the secretary system of

udders have been continued. A gravity system consisting of an elevated tank and pipe line has been installed to replace the hand pump previously employed in filling amputated udders. The new system greatly facilitates the work and gives a more uniform pressure with the different specimens and more comparable results than did the old system. The capacities of two lactating udders, five nonlactating udders, and the udder of one heifer less than 2 years of age have been determined during the year. The results are in accord with those previously reported. The capacities of 39 udders, determined since the beginning of this study, are shown in Table 3.

TABLE 3.—*Average quantity of fluid and milk equivalents accommodated by the udders of 39 animals*

Condition of animal	Animals	Capacity	Milk equivalent
	Number	*Cubic centimeters*	*Pounds*
Lactating	16	19,454	44.21
Nonlactating	13	12,260	27.86
Nonlactating (beef)	1	3,620	8.23
Heifers and young cows, never pregnant	7	4,074	9.26
Calves under 4 months	2	212	.49

Post-mortem milking tests to determine the quantity and composition of milk in the udder at the commencement of milking have been continued with one additional cow. Before being killed she was producing an average of 25.8 pounds at a milking, and 17.8 pounds, or 68.99 per cent of this quantity, was milked by hand from the amputated udder. A total of 11 cows has been included in this test. For the first 4 cows, where the conditions of killing were not entirely controlled and where the amputated udders were not held at body temperature, the average quantity of milk recovered was 9.22 pounds, or 61.1 per cent of the quantity obtained from the same udders at corresponding milkings before death. The 7 udders studied under controlled conditions of killing and held at body temperature after amputation yielded an average of 14.83 pounds, which was 75.32 per cent of the quantity obtained from them at corresponding antemortem milkings. The results obtained in this study indicate that milk secretion is largely continuous and that a very large proportion of the milk obtained at any milking is present in the udder before the milking process is commenced. Chemical analyses of the milk obtained from amputated udders have shown the outstanding difference in composition to be a butterfat test only about half as high as that obtained from the same udders before death and amputation. Further attempts to determine the cause of this low butterfat test have been only slightly successful. Solvents pumped into the secretory system after the completion of the post-mortem milking and subsequently removed did not contain significant quantities of butterfat.

COMPARATIVE CONFORMATION AND ANATOMY OF DAIRY AND BEEF ANIMALS

A detailed study of the differences in outward form, size of internal organs, skeletal structure, and mammary development between a highly specialized dairy cow and a highly specialized beef cow has been completed. The two cows differed greatly in external form but were relatively similar in internal anatomy and skeletal structure. In mammary development the cows differed greatly, the beef cow's udder being almost lacking in secreting tissue. Because of the results of this investigation an experiment was begun to determine the difference between the udders of dairy cows and of beef cows kept under dairy conditions. This experiment has been in progress for more than a year at the dairy experiment station at Jeanerette, La., in cooperation with the division of animal husbandry, Bureau of Animal Industry. Four first-calf Hereford heifers were placed in the dairy herd and were fed, milked, and handled the same as the dairy cows. Three others of similar age and breeding were placed in the beef herd as checks. One in each group was between 3 and 4 years of age at the time of calving. The others were approximately 1 year younger. The production of the four beef cows kept in the dairy herd is shown in Table 4.

TABLE 4.—*Production of four beef cows in Jeanerette, La., herd*

Cow No.	Full months of lactation period	Highest production for 1 month of—		Total production of—	
		Milk	Butterfat	Milk	Butterfat
	Number	*Pounds*	*Pounds*	*Pounds*	*Pounds*
2	5	52.1	3.05	125.0	6.49
5	6	57.3	2.32	215.1	8.20
6	5	30.1	1.51	73.7	3.39
16	10	272.2	12.39	1,725.7	87.86

The seven cows were shipped to Washington, D. C., and their conformation was recorded in photographs and measurements. Their internal anatomy was determined by slaughtering, and their udders were removed to make possible a study of their gross and microscopic structure. The capacity of the secretory system of each has been measured and is expressed in milk equivalent. For the four that had been milked through one lactation period the udder capacities ranged from 2.27 to 10.11 pounds and averaged 4.97 pounds. Similar capacities for the three that had been kept under beef-herd conditions ranged from 2.23 to 11.8 pounds and averaged 7.62 pounds. The udders have not been sectioned, but the capacities noted seem to indicate that only a small quantity of mammary tissue will be found in any of them.

FEEDING AND MANAGEMENT EXPERIMENTS

Experiments at Beltsville show that Jersey cows will eat enough No. 2 alfalfa hay and corn silage on the average to provide for maintenance and 10 pounds of milk per day, and that Holsteins will eat enough for maintenance and 16 pounds of milk per day. It also has been estimated from the feeding standards that 1 pound of Holstein milk requires 0.4 to 0.45 pound of grain and that 1 pound of Jersey milk requires 0.55 to 0.6 pound of grain. A Jersey cow giving 10 pounds of milk per day, therefore, needs no grain, but for every pound over 10 she should receive 0.55 or 0.6 pound of grain. Similarly, a Holstein cow giving 16 pounds of milk per day needs no grain, but for every pound over the 16 she should receive 0.4 or 0.45 pound of grain.

For the past two winters this system has been tried out with satisfactory results. Altogether 39 Jerseys have been fed for 143 cow months and 31 Holsteins for 76 cow months. From the fact that the Jerseys gained an average of 3.5 pounds each cow month and the Holsteins 7.1 pounds, it appears that the cows were properly nourished so far as quantity of feed was concerned. The Jersey average was comparatively low because some of the cows had just calved and were therefore normally losing weight and some were being fed timothy and clover hays.

Silage was fed at the rate of 3 pounds a day for each 100 pounds weight of the animal. Hay was given in such quantities as would be consumed without undue waste. The Jerseys ate an average of 12.9 pounds of hay a day; the Holsteins, 17.2 pounds. The amount consumed was approximately proportional to the size of the animals.

Feeding barley infested with Gibberella saubinetii.—An experiment has been conducted to ascertain the palatability of barely infested with *Gibberella saubinetii* (scab). The cows used were 4 Jerseys, 6 Holsteins, and 2 grade Holsteins, yielding from 14.1 to 41.4 pounds each of milk daily. The barley ration consisted of a mixture of ground barley (4 parts), wheat bran (2 parts), and cottonseed meal (1 part). The amount of barley received by each cow daily ranged from 2.18 pounds to 8.2 pounds with an average of 5.6 pounds. This was fed along with all the alfalfa hay the cows would eat. The ration for comparison was the regular herd mixture of hominy feed (100 parts), wheat bran (100 parts), ground oats (100 parts), cottonseed meal (50 parts), and linseed meal (50 parts).

The barley ration was eaten readily and was followed by no ill effects upon the health of the animals or the milk flow.

Feeding clay.—It has been observed that the cows at Beltsville are very fond of fresh, clean clay. They will reach under the fences and dig around fence posts to get it. Since it has been shown that animals suffering from a deficiency of phosphorus will chew bones, presumably to satisfy their demands for this mineral, it has seemed reasonable to assume that an animal's fondness for clay is prompted by some need for the minerals supplied by the clay.

Dry, clean clay is being fed to two grade Holsteins in the test barn in such amounts as they will eat when it is kept before them in a special box provided for the purpose. Since January 1, 1929, one cow has eaten the clay at the rate of almost one-third of a pound a day, the other at the rate of about one-twelfth of a pound a day. No bad effects have been observed.

An experiment is being made to determine, if possible, what constituent of the clay the cow craves.

Feeding young calves.—Two groups of calves each consisting of seven Holsteins born in February, March, and April of this year are being fed the Beltsville calf meal in the dry state rather than mixed with warm water. Both groups receive the meal for three months. To one group it is fed dry; to the other wet. After three months both groups are fed the same, and the

regular calf grain is used instead of the calf meal. A total of 300 pounds of whole milk is fed to each calf, 10 pounds a day at first, then it is gradually reduced until it is discontinued at 50 days.

The calves have remained in good health, and so far both groups have done equally well. Although the gains are not so great and the calves do not look so well as do those fed skim milk, on the whole the method of feeding appears fairly satisfactory.

Comparison of palatability of green and brown hay.—An experiment was conducted to compare the palatability of hay heated enough in the mow or stack to become brown, and hay retaining much of its natural green color.

Two lots of first-cutting alfalfa were placed in the mow and separated by jute sacks from the hay piled on top. One lot had lain in the swath one day; the other two days. Bags of each kind of hay buried in the middle of each mass showed losses in weight from green to air dry of 49.5 and 33.7 per cent, respectively. The wetter lot was the darker and the more brittle of the two.

Six Holsteins of good production fed the browner hay for one week ate an average of 14.4 pounds per day. When fed hay made in the ordinary way (No. 3 hay or worse) they ate 16.7 pounds per day and when receiving the other lot of brown hay 16.8 pounds per day. They were then fed United States No. 2 Michigan hay, and they consumed 17.9 pounds daily.

This hay was not made more palatable by browning in the mow; and while chemical analyses have not yet been made of the samples, there is little doubt that the browning has resulted in a greater loss of feed nutrients.

Silage experiments.—A continuation of the practice of placing corn in the silo without tramping or distributing has been attended by complete success. Records for the past three years show that on the average the spoilage on top of a silo 14 feet in diameter was 3,440 to 3,590 pounds in 2 or 3 months; 4,860 to 6,815 pounds in 5 or 6 months; and 5,250 to 7,430 pounds in 9 or 10 months.

A crop of first-cutting green alfalfa amounting to 10,430 pounds was placed in the silo along with 8,500 pounds of corn. The resulting silage was entirely satisfactory. A short feeding test indicated a slight superiority of this mixture over a ration of alfalfa hay and corn silage.

First-cutting alfalfa alone placed in small silos made excellent silage in every instance. The alfalfa was placed in one silo as soon as mowed, in another after it had lain in the swath about three hours, in the third after it had lain in the swath from about noon one day until 10 o'clock the next morning. Preliminary figures on the moisture contents of the three silages indicate that all were within the moisture limits set by Eckles (50 to 70 per cent).

A considerable quantity of smart weeds and foxtail that had come up in a new seeding of alfalfa was placed in the silo and later fed with fair results. These plants, ordinarily refused by cows in either the dry or green state, were made more palatable by ensiling them. Similar results attended the making of these plants into stack silage.

Milking three times a day compared with milking twice a day.—Previous investigations at this station have shown that the increase from milking cows three times a day for short periods of 30 or 40 days is 11 to 12 per cent over twice-a-day milking. Since these investigations were reported six cows have been milked for two lactations each and two for three lactations each, making in all 18 lactations. In 8 of these the cows were milked twice a day and in 10 three times a day. The length of these periods varied from 217 to 365 days. Conditions were the same for all lactations except the number of times a day the cows were milked.

It was found that the cows when milked three times a day gave 21.2 per cent more milk and 22.4 per cent more butterfat. Much of this increase was due to the fact that the cows milked three times a day held up better in their milk flow. The decline in production from the first to the last 30 days of the lactation was only about one-half as great with the cows milked three times a day as with those milked twice.

In order to determine whether milking three times a day is a profitable practice, a person must know not only the probable increase in production but also the quantity and cost of the grain needed for the increased production, the cost of the extra milking and the value of the increase in production. As these vary with the locality and the individual dairyman, no definite answer is possible. It must be figured out individually.

Under conditions similar to those prevailing at Beltsville, the following estimate is made, taking, for example,

a Holstein cow yielding 40 pounds of milk a day when milked twice a day:

Increase when milked three times a day, 40×0.22, 8.8 pounds milk.
To produce 8.8 pounds milk there will be required 3.5 pounds grain.
3.5 pounds grain at $45 a ton will cost 7.9 cents.
The extra milking, with labor at 35 cents an hour, will cost 4.4 cents.
Total additional cost per cow a day, 12.3 cents.
Value of product, at $3 per 100 pounds, 26.4 cents.
Net profit through milking three times a day, 14.1 cents per cow a day.

A cow giving 30 pounds and one giving 20 pounds when figured in a similar manner show net profits through milking three times a day of 9.5 and 5.1 cents, respectively.

FIELD STATIONS

On May 1, T. W. Moseley, who had been in charge of the dairy work at the Huntley station, was transferred to the Beltsville (Md.) station as superintendent. D. V. Kopland, formerly in charge of the dairy work at the Ardmore (S. Dak.) station, was transferred to the Huntley station on June 1 and is now in charge of the dairy work. Ray Smith succeeded D. V. Kopland at the Ardmore station.

At the Huntley (Mont.) station an experiment was started this year, to continue for several years, to show the comparative efficiency for milk production of irrigated tame grasses which are grazed, clipped and fed green, made into hay, and ensiled. The more important phases of the first season's results are shown in Table 5.

In this experiment one cow consumed 122 pounds of the green grass in one day, and several ate more than 100 pounds. The average daily consumption was 75.57 pounds per cow. The moisture content of the first cutting, which was made in May, was 80 per cent and gradually decreased to 65 per cent on August 24, when the clipping was discontinued because of insufficient growth.

Two cuttings of grass were placed in the silo, one on top of the other. The first cutting, on account of its maturity, did not ensile well and was not suitable for feeding. The second cutting made excellent silage, but there was only a sufficient quantity to be fed 11 days. The test indicates that cows will eat relatively large quantities of grass silage, the average daily consumption being 83 pounds per cow. The smallest amount eaten by a cow was 35 pounds, and the largest was 110 pounds per day.

Results for 10 years are now available on the experiments to determine the maximum carrying capacity of an acre of irrigated tame-grass pasture. The 10-year average shows a grazing season of 138 days and 303.4 cow days per acre. The average annual production of tame grass per acre was equivalent to 6,990 pounds of milk and 266.7 pounds of butterfat. This pasture has been top-dressed annually with 15 tons of barnyard manure.

TABLE 5.—*Comparative feeding value of pasture grasses fed as specified at Huntley, Mont., 1928*

Items of comparison		Grazed	Clipped and fed green	Hay	Silage
Average daily number of cows per acre		1.84	2.9		
Total cow days per acre		182	287	228	264
Average weight of cows	pounds	1,399	1,258	1,317	1,319
Average loss in weight per acre	do	314	238	101	1,897
Production per acre:					
Milk	do	4,575	4,040	5,195	7,903
Butterfat	do	177	171	181	308
Yield of hay, clipped grass, and silage per acre	do		21,392	7,481	22,130
Yield of dry matter per acre	do		5,937	[1] 6,733	[2] 6,639
Average daily consumption per cow	do		75.6	32.8	83

[1] Air dry.

[2] Green weight.

From the irrigated sweetclover pasture (using only the second year's growth) a grazing season of 108 days was obtained with 169 cow days per acre for a 2-year average. A production of 4,080 pounds of milk and 162 pounds of butterfat was obtained per acre. The cows seemed to prefer the yellow sweetclover to the white.

Two cows were fed alfalfa silage (to which was added 1 part of beet molasses to 20 parts of alfalfa silage at time of filling silo) and ordinary corn silage for a period of 138 days. This experiment was conducted for the purpose of finding out whether cows could be fed silage alone without lessening their production.

During this feeding period cow H–48 consumed an average of 62 pounds of silage per day with a maximum daily consumption of 92 pounds. Cow H–49 consumed an average of 56 pounds per day, with 78 pounds for her highest day's consumption. The two cows showed a preference for the corn silage. They lost an average of 177 pounds in weight during the feeding period.

Cow H–48 was producing 49.3 pounds of milk per day when the experiment started. On the fifteenth day her production had dropped to 38 pounds per day. It continued to drop until the forty-seventh day, when it reached 30.9 pounds and continued at this level until the end of the trial. Between the first and fourth full months on the silage ration the milk production of cow H–48 dropped 17.4 per cent and the butterfat production 18.8 per cent, whereas between the first and fourth full months the milk production of cow H–49 dropped 6.8 per cent and the butterfat production 25 per cent.

At the Ardmore, S. Dak., station an experiment was in progress this year to determine the comparative efficiency of Sudan grass for milk production and the yields when it was grazed for pasture, when it was clipped every 15 days and fed green, when it was matured for hay, and when it was ensiled. Table 6 shows the results of the first year's work.

TABLE 6.—*Yield per acre of Sudan grass fed as specified at Ardmore, S. Dak., 1928*

Items of comparison	Grazed	Clipped and fed green	Hay	Silage
	Cow days	*Pounds*	*Pounds*	*Pounds*
Total yield per acre	47.5	[1] 6,675.0	3,470	6,971.0
Yield dry matter per acre		1,787.0	3,260	2,218.0
Yield crude protein per acre		212.4	358	230.6
Yield crude fiber per acre		454.6	782	611.0

[1] Green weight.

The carrying capacity of sweetclover pasture, as in previous years, proved very unsatisfactory at this station. Because of the bitter taste, which was probably due to the high coumarin content, it was difficult and in some cases impossible to get the cows to eat the sweetclover.

A very satisfactory grade of sweetclover silage was made this past season. Apparently the fermentation process destroyed or offset the bitter taste. The sweetclover used in making this silage was about 3½ feet high when cut on June 28. It was just coming into bloom. Corn silage from the year previous was blown into the silo at the rate of 1 part of corn silage to 20 parts of sweetclover. The resultant silage was dark green in color, heavier than corn silage, and had a pungent odor, which became less pronounced as the feeding season advanced. The silage kept very well, and there was practically no spoilage.

For a period of 126 days this silage was fed to four cows, two of which were dry. Two of these cows were given silage alone, and the other two received in addition a small quantity of oat straw daily in order to furnish additional dry matter. The cows did not relish the silage, although when forced to eat it they consumed as much as 90 pounds per day. Individual cows reacted differently. One cow refused it altogether after 30 days. The addition of a small quantity of straw to the ration did not materially affect the quantity of silage consumed. The cows lost an average of 182 pounds in weight. The production of the lactating cows dropped greatly. Both of these cows, one producing 21 pounds and the other 16 pounds of milk daily at the start, were dry at the end of the eleventh week. The production of one cow that freshened during the feeding period dropped materially. The results indicate that sweetclover silage as a wintering ration for dry cows may prove valuable. It is probable that under dry-land conditions and in those years when other feed crops fail sweetclover could be placed in an inexpensive silo, such as a trench, and be the principal means of carrying cattle through the winter.

At the Mandan, N. Dak., station the principal effort for the past year has been centered on establishing a foundation herd of cattle, working out a suitable feed-crop growing plan, and planning feeding and management experiments. Nine females and a proved bull were shipped to Mandan from the Huntley station, and three heifers were shipped from the Utah Agricultural College. Most of the females have calved and are now on test. The herd now numbers 21 head.

The crop yields on the farm were very good, considering that the land was freshly broken sod. Oats yielded 55 bushels and barley 24 bushels per

acre. Corn yielded only 3.3 tons of silage per acre. Sudan grass for hay yielded 1.3 tons per acre. Thirty acres of alfalfa have been seeded for hay. Five acres of sweetclover have been seeded this year for pasture experiments.

Experimental work has been started with an ice well or pit. A pit, 8 by 8 by 8 feet, was dug and boarded up with lumber. A small house with removable floor was erected over this. Last winter, during extreme cold weather, a few inches of water was run into this pit every two or three days and allowed to freeze. As a result of this, a solid block of ice accumulated which was estimated as weighing 14.7 tons. Milk and dairy products are lowered and set on this block of ice during the summer. An automatic, self-recording thermometer has been installed, and data are being obtained as to how long this ice will last and its efficiency in keeping dairy products cold.

At the Woodward, Okla., station, interesting data have been obtained on the comparative feeding value and yields of nutrients per acre of Sudan-grass hay cut at three stages of maturity. Table 7 shows the yields and analyses of the crop at the indicated stages of cuttings.

TABLE 7.—*Comparative yields and analyses of Sudan-grass hay cut at three stages of maturity at Woodward, Okla., 1928*

Items of comparison	Stages of maturity		
	First heads out	Fully headed	Milk or soft dough
Yield per acre, air cured ----------pounds--	3,409	4,180	4,217
Dry matter per acre_do----	3,000	3,579	3,711
Percentage of crude protein----------	11.9	8.1	5.6
Crude protein per acre ----------pounds--	374.7	305.1	218.7
Percentage of crude fiber--	27.5	32.8	32.4
Crude fiber per acre ----------pounds--	868.4	1,173.9	1,265.6

Hay cut when first heads appeared contained 11.9 per cent crude protein, whereas hay cut when fully headed and in the milk or soft-dough stages had a protein content of only 8.1 and 5.6 per cent, respectively. The total yield of air-cured hay was considerably higher for the more mature stages, but the yield of crude protein per acre was about 156 pounds more for the first stage than for the last. The results obtained indicate the possibility of increasing the protein per acre by cutting Sudan grass before it gets too mature.

An experiment of 28 days' duration was carried out to compare the feeding value and the average daily consumption per cow of these three stages of hay, alfalfa hay being used as a check. Four groups of cows were used. The preliminary results are shown in Table 8.

TABLE 8.—*Comparison of consumption of hay and decrease in milk production of cows fed Sudan grass hay cut at three stages of maturity (alfalfa hay as check)*

Items of comparison	Stages of maturity			
	First heads out	Fully headed	Milk or soft dough	Alfalfa check
Decrease in milk production---------per cent--	15	20	19	10.1
Average daily consumption per cow--pounds--	28.7	19	20.7	27.8

At the Jeanerette, La., station the health and breeding condition of the herd have steadily improved during the past two years. Because of infection of the herd with Texas fever, the loss of many cows during the 1927 flood, and the impaired breeding efficiency of the remainder, experimental work has been practically at a standstill.

An experiment to determine the effect of rotating pasture every 21 days and top dressing with superphosphate (acid phosphate) on the carrying capacity of native-grass pasture has been carried on during the pasture season of 1928. Because of the above-mentioned herd conditions, it was necessary to use some dry cows and heifers in this pasture work. The results of this experiment are shown in Table 9. Pasture rotation apparently had little effect. Top dressing at the rate of 160 pounds of superphosphate per acre increased the carrying capacity 81.9 cow days over the pasture not rotated and not top dressed.

TABLE 9.—*Effect of rotation and top-dressing with superphosphate (acid phosphate) on carrying capacity of native grass pasture at Jeanerette, La., 1928*

Items of comparison	Not top-dressed, not rotated	Rotated, not top-dressed	Rotated and top-dressed with 160 pounds superphosphate annually
Length of grazing season.....days..	232.5	232.5	232.5
Cow days per acre....	244.6	247.5	329.4

A Jersey cow, Iberia's Torono of Hillside 540495, recently completed a register-of-merit test in mature form, producing 16,492 pounds of milk and 865.96 pounds of butterfat in one year. She finished her test on May 26 and calved on the following June 19. She is a daughter of Interested Veda's Prince and out of a daughter of Hillside Torono, the first two proved sires to be used in this herd.

The work at the Pontiac, S. C., station has for the most part been preliminary to the establishment of a herd of Guernsey cattle and getting a cropping system worked out. A pasture of considerable acreage has been cleared and seeded.

A foundation herd of 10 purebred heifers and a proved bull have been purchased. The heifers are all daughters or granddaughters of good proved sires. The bull is Gallant Cavalier 83960. His first five daughters to finish records produced, on a maturity basis, an average of 12,298 pounds of milk and 626.77 pounds of butterfat. Their five respective dams averaged 11,043 pounds of milk and 590.76 pounds of butterfat, an increase in favor of the daughters of 1,255 pounds of milk and 36.01 pounds of butterfat.

All the field-station herds have recently been tested for abortion by the Bureau of Animal Industry of this department. Table 10 shows the results of these tests.

TABLE 10.—*Condition of field-station herds in respect to abortion*

Location of herd	Animals tested	Abortion reactors
Ardmore, S. Dak.	28	3
Huntley, Mont.	37	0
Mandan, N. Dak.	13	1
Woodward, Okla.	33	0
Jeanerette, La.	41	10
Pontiac, S. C.	11	0

In those herds where abortion reactors are present, steps have been taken for proper control of the situation.

Table 11 shows the size of the herds at the various stations, together with the number of young bulls on hand and the number placed with cooperators to be proved.

TABLE 11.—*Size of herds and bull-proving work at field stations*

Location of herd	Females	Bulls, including herd bulls	Total animals	Bulls placed with cooperators	Bulls proved this year
Ardmore, S. Dak.	36	7	43	15	1
Huntley, Mont.	37	8	45	42	5
Mandan, N. Dak.	19	2	21	------	------
Woodward, Okla.	44	10	54	20	1
Jeanerette, La.	44	13	57	21	1
Pontiac, S. C.	10	1	11	------	------
Total	190	41	231	98	8

DAIRY WORK AT FEDERAL PRISONS

Help has been given the Department of Justice in the management and feeding of its dairy herds located at the five Federal prisons. Personal visits have been made to all these institutions. During the year six young bulls from the bureau herd have been placed in the prison herds. At the suggestion of this bureau, trained dairymen are now being employed to take charge of the dairy herds.

DIVISION OF MARKET-MILK INVESTIGATIONS

ERNEST KELLY, *Chief*

DAIRY SANITATION

Bacterial studies in milk plants were completed during the year. A total of 97 plants, located in 19 cities in 10 States and the District of Columbia, have been studied. These plants ranged in size from 100 to 30,000 gallons of milk per day. Thus a very fair average distribution as to geography, climate, and size of plants was obtained. The object of the study was to ascertain where bacterial increases occurred as the milk passed through the plant and the reasons for these increases. Tests at each plant were made on five consecutive days, samples being taken of the raw milk before pasteurization, the hot milk after pasteurization, milk from the bottom of the cooler, milk in the bottle, and the same milk after storage in the cold-storage room until the next day. In

all, over 2,400 samples of milk were examined.

The raw milk contained an average of slightly over 1,000,000 bacteria per cubic centimeter; and the milk after pasteurization contained an average of 28,600 per cubic centimeter, which was a bacterial decrease of about 97 per cent. It was found that plant practices increased the count of the pasteurized milk slightly over 38 per cent, or to an average of 39,500 per cubic centimeter. An increase of approximately 4,000 bacteria per cubic centimeter was due to contamination from the milk cooler, while about the same increase was due to the bottle-filling machine. It was found that the bacterial count of the milk in storage increased nearly 3,000 per cubic centimeter.

Forty-one of the samples showed pin-point colonies after pasteurization. In this group of samples the bacterial reduction because of pasteurization was only slightly over 93 per cent, and the average count of the pasteurized milk was 106,800. A slight decrease in bacterial count resulted as this milk passed through the apparatus. This was undoubtedly due to the failure to survive of some of the specific types of organisms which had escaped pasteurization, which more than counteracted any contamination from the apparatus.

This work showed very clearly that on an average these plants, many of them with equipment and methods not of the best, obtained good results from pasteurization but that they handled the milk unsatisfactorily from a bacteriological standpoint. The studies have brought out the vital necessity of proper sterilization of coolers and bottling machines especially and the better cooling and circulation of air in cold-storage rooms. The work done has already proved helpful to a number of dairies, especially in rearranging their cold-storage facilities.

The study showed a direct relation between pasteurization temperature and efficiency. The lowest constant temperature used was between 140° and 141° F., at which the average count was 59,600, or a reduction of 96 per cent. The highest constant temperature noted was between 146° and 148° F., at which the average bacterial count was 12,700 per cubic centimeter, or a decrease of 98.34 per cent.

The milk ordinances from 402 cities have been digested and the salient features of each one entered on cards. This gives a ready reference of the fundamental requirements of most of the important cities in the country. This tabulation has been extremely useful in studying sanitary requirements and in answering requests regarding specific matters of legislation.

The work on fly control at the dairy experiment farm at Beltsville, Md., has been continued. The total flies caught in traps during the season of 1928 was 29⅜ gallons, or 48 per cent less than in 1927. The trapping has shown a decreasing number of flies every year since the work was started. Spraying was continued, and 220 gallons of spray were mixed and used during the season. A water-pyrethrum spray was tried but did not seem to give as good results as the oil spray. A concentrated pyrethrum-oil mixture gave excellent results. Test piles of manure left on the farm through the winter showed live larvæ on January 31, 1929, a fact which seems to indicate that in this latitude large piles of manure in not too exposed places will harbor flies in the larval or pupal state throughout the winter. Additional experiments in which a proprietary preparation, ground hellebore, and superphosphate were used for treating the ground under the manure piles gave no beneficial results.

The bureau has continued its supervision over milk delivered by four dairies to the Departments of the Treasury, Commerce, and Agriculture. The dairies were scored once each month, and samples were taken practically once a week. When the count exceeded 100,000 per cubic centimeter the dairy was notified and steps were taken immediately to discover the cause and correct the condition.

During the year the farm at Beltsville was inspected each month. It had an average score of 96.2, with a high score of 98.2 and a low score of 95. These scores are all slightly higher than for the year preceding.

Eleven inspections of the Naval Academy dairy were made during the year. The average score for this dairy was 97.3, and the average bacterial count was 2,390 per cubic centimeter. Two of the samples showed pin-point colonies, indicative of garget, and had high counts. If these two counts were eliminated, the average would be 1,330 per cubic centimeter.

The bureau has continued its cooperation with the Columbia Institute for the Deaf, and during the year has made 5 inspections and 30 bacteriological examinations of the milk.

The surprise milk-scoring method of education and control introduced in the Western States has been successful

over a period of about 15 years and is in use in all of the principal cities of California, Oregon, Washington, Idaho, Montana, Wyoming, Nevada, Utah, and Colorado. This work was discontinued by the bureau in April, 1929.

MILK-PLANT MANAGEMENT

Studies on the effect of plant arrangement, equipment, and methods of operation on the breakage of bottles have been continued during the past year in Syracuse, Rochester, and Buffalo, N. Y. Twenty-three plants in these cities were covered completely. In addition all the field data collected in the survey of Greater New York and near-by cities were tabulated.

The information obtained is aiding milk dealers to reduce their breakage. For example, in 1927 one company in the Middle West doing a large business had a breakage of about 24 pounds of glass per 1,000 bottles filled when the first survey was made by the bureau. This company became interested in the work and regularly collected data and reported them to the bureau. Complete daily records for 1928 showed the average breakage to be only 9.7 pounds of glass per 1,000 bottles filled. These studies have also resulted in a number of dairies installing weight systems to keep a careful check on bottle breakage.

Briefly, the results of these studies indicate the following:

Plants handling fewer than 10,000 bottles daily had a lower average breakage than plants handling more than 10,000 bottles. The plants in the former group had a breakage of 7 pounds per 1,000 bottles filled, while the plants in the latter group had a breakage of 12.4 pounds. In plants handling over 10,000 bottles daily, the size of the plant appeared to have no direct influence on breakage.

Moving bottles from floor to floor and to a lesser extent the vertical lifting or lowering of bottles tended to increase breakage.

The hand system of moving bottles (either carrying or pulling with hooks) resulted in a breakage of only 1 pound per 1,000 bottles, while the truck system resulted in a breakage of 1.8 pounds, and the conveyor system resulted in the breakage of 2.3 pounds. In comparing these three systems, however, several things should be considered. The hand system was used principally in plants where bottles were to be moved short distances, trucks were used for moving bottles over medium distances, and conveyors for longer distances and for moving bottles between floors.

The type of bottle washer and the system of washing and filling apparently had an influence on the breakage of bottles, which was less in plants using the soaker washers and the direct system of washing and filling than in plants using the in-the-case washers. The total breakage in 95 plants using the soaker type was 11.9 pounds per 1,000 bottles, while the breakage in 25 plants of the other type was 13.8 pounds, which was an increase of more than 15 per cent. In plants using in-the-case washers extra handling of the bottles for stacking and cooling was usually required. Furthermore, the inversion of bottles in the case allowed them to have considerable play between crosspieces, resulting in the bottles striking together and frequently cracking.

Many additional factors were found which seemed to influence breakage to a considerable extent. Some of these were slippery bottle rests in the fillers caused by milk and especially cream slopping on them, steep conveyors and conveyors with sharp turns.

Studies made at 67 country milk receiving and cooling stations located in Pennsylvania, New York, and Vermont showed that as the volume of milk handled increases both the direct costs and the indirect costs per hundred pounds tend to decrease. A study was made at 35 plants to determine the total investment in buildings and equipment per hundred pounds of milk handled. It was found that this investment ranged from $247.91 in plants handling from 500 to 1,000 gallons daily to $65.32 in plants handling over 5,000 gallons of milk daily. This shows strikingly one of the causes of the high overhead costs at the small shipping stations.

MARKET MILK AND CREAM

VISCOSITY OF CREAM

The project on factors affecting the viscosity of cream has been carried on in considerable detail during the year, and the following results have been obtained:

Cream containing 30 per cent butterfat from milk pasteurized at 62.5° C. before being separated and then separated at the pasteurizing temperature had a lower viscosity than cream first separated at a temperature of 26° C. and then pasteurized.

Cream from milk pasteurized and rapidly cooled to the separating temperature had a lower viscosity than cream pasteurized after separation, but the viscosity was greater than with cream separated after pasteurization without cooling.

Cream from milk pasteurized and slowly cooled in the vat to the separating temperature showed a greater viscosity than that pasteurized after separation.

The viscosity of cream containing 30 per cent butterfat increased as the separating temperature decreased. Such cream separated at 18° C. had at 5° C. a viscosity 12.7 per cent greater than the same cream separated at 36° C.

Considerable work has been done on the effect of homogenization on the viscosity of cream. This work has not as yet been completed, but from its present status the following deductions are indicated:

The viscosity of cream increases as the homogenization pressure increases.

When a homogenization pressure of 2,000 pounds per square inch was used with cream

containing 20 per cent butterfat, the lowest increase in viscosity over the original pasteurized cream was at a temperature of 70° C. (158° F.). This increase was only 23 per cent over the viscosity of the original cream, whereas when the pasteurizing and homogenizing temperature was 50° C. the percentage increase in viscosity was 153.8. From 70° to 88° C., the highest temperature used, the viscosity increased slightly.

From a commercial standpoint it appears that a pasteurizing and homogenizing temperature of 62.5° C. (144.5° F.) gives the greatest increase in viscosity at temperatures at or above the safety line of pasteurization.

The viscosity of cream containing 20 per cent butterfat increases with an increase in the solids not fat. If the percentage of solids not fat of such cream is above normal, the increase in viscosity is more pronounced upon homogenizing the cream, whereas if the percentage of solids not fat is below normal, the relation between the viscosity of homogenized and unhomogenized cream does not vary.

Microscopic studies show that the viscosity of pasteurized and homogenized creams is accompanied by an increased clumping of fat globules.

FLAVOR AND ODOR

Studies made to determine the effect of safflower oil meal on the flavor and odor of milk show that (1) the grain ration fed to dairy cows either before or after milking may consist of 33⅓ per cent of safflower oil meal without affecting either the flavor or odor; and (2) no abnormal flavors which can be attributed to safflower oil meal developed upon aging the milk for five days at 5° C.

In other experiments barley infected with scab (*Gibberella saubinetii*) was fed to determine the quality of the milk produced. When the grain ration fed to dairy cows either before or after milking is 57 per cent barley infected with *G. saubinetii*, it does not affect either the flavor or odor of the milk produced. No abnormal flavors which can be attributed to the barley developed upon aging for five days at 5° C.

Experiments showed that when alfalfa silage was fed to dairy cows before milking it seriously affected the flavor and odor of the milk. When it was fed to dairy cows immediately after milking, however, it affected neither the flavor nor the odor of the milk produced at the next milking. There appeared to be no difference in the effect of alfalfa silage on the flavor of milk when the percentage of dry matter in the silage was increased from 33 to 35 per cent. When the percentage of dry matter was increased to approximately 45 per cent, however, there was a slight decrease in the intensity of the off flavors and odors produced.

DIVISION OF DAIRY-HERD-IMPROVEMENT INVESTIGATIONS

J. C. McDowell, *Chief*

The division of dairy-herd-improvement investigations was created May 1, 1929, and took over that part of the work of the dairy-introduction project that pertained to dairy-herd-improvement associations and bull associations. The investigational work includes studies of the yearly individual cow records, field work in connection with methods, field work relating to bull associations and other organizations to promote better breeding in the herds on test, a study of feeding practices in dairy-herd-improvement association herds, and a study of the trend of the dairy industry. This report covers the work done under the old as well as under the new organization.

From January 1, 1928, to January 1, 1929, the number of regular dairy-herd-improvement associations in this country increased from 947 to 1,090. This is a gain of 143 associations, or 15 per cent. The number of cows on test increased from 414,891 to 465,804. This is a gain of more than 12 per cent. Altogether 26,182 herds were on test—approximately 24 herds to the association, 18 cows to the herd, and 432 cows per association. From January 1 to June 1, 1929, the number of records received from the field was 65 per cent greater and the number of sires proved was 69 per cent greater than for the same period last year.

On January 1, 1929, there were 10 bimonthly dairy-herd-improvement associations in four States. In these associations 6,419 cows were on test, approximately 642 per association. During the past year in Alabama alone four such associations were organized, in which 4,281 cows were placed on test, or 1,070 cows per association.

DAIRY-HERD-IMPROVEMENT ASSOCIATION STUDIES

Table 12 shows a comparison of dairy-herd-improvement association cows by years as to average production, feed cost, and income over cost of feed. This table shows a gain in number of records tabulated each successive year since 1924, a gain in production of milk and butterfat per cow, and generally a gain in income over cost of feed per cow. Production per cow, however, is now so high that it is becoming very difficult to increase it. The table shows that in 1928 the yearly milk production per cow increased only

54 pounds and the yearly butterfat production only 2 pounds over that in 1927. The production of both milk and butterfat, however, is more than 60 per cent above that of the average dairy cow in the United States.

TABLE 12.—*Comparison of cows in dairy-herd-improvement associations by years, as to average production, feed cost, and income over cost of feed*

Year	Associations tabulated	Records (cow years)	Average production of—		Average cost of feed	Average income over cost of feed
			Milk	Butterfat		
	Number	*Number*	*Pounds*	*Pounds*	*Dollars*	*Dollars*
Prior to 1920	120	37,362	5,989	247	53	59
1924	129	32,091	7,092	279	68	94
1925	380	98,704	7,189	284	67	89
1926	476	127,617	7,316	289	69	101
1927	532	142,084	7,410	293	73	111
1928	656	201,590	7,464	295	77	116

A study of 152,000 yearly individual records of cows on test in 1928 showed a rapid gain in income over cost of feed as butterfat production advanced from 100 to 500 pounds per year. The cows having an average butterfat production of 100 pounds a year had an average income over cost of feed of $15. At 200 pounds the income above feed cost was $64; at 300 pounds, $113; at 400 pounds, $165; and at 500 pounds, $215. Briefly stated, as butterfat production per cow is multiplied by 5, the income over cost of feed is multiplied by 14. It would require 14 cows, each producing 100 pounds of butterfat a year, to bring in as much income over feed cost as one cow that produces 500 pounds.

A study showing the relation of size of herd to production per cow was completed for each of the two testing years 1927 and 1928. For each year it was discovered that the herds of 10 cows or fewer had a higher average production of butterfat per cow than the herds of 11 to 25 cows. The former averaged more than 300 pounds of butterfat per cow per year, whereas the latter averaged less than 300 pounds.

A study of the yearly individual records of more than 219,000 dairy cows for the testing years 1926, 1927, and 1928 showed that for cows of the same breed and age the largest cows produced the most milk and butterfat and yielded the largest average income over cost of feed. On an average for each gain of 100 pounds weight per cow the income above feed cost increased by about $5.

As in all previous tabulations the records of the cows on test in 1928 showed that the cows that freshened in the fall produced a little more milk and butterfat and a somewhat higher income above feed cost than cows that freshened at some other time of year. The difference, however, was the smallest obtained in any study on this subject made by the bureau.

A study of the records of 74,000 grades and 36,000 purebreds showed that the purebreds excelled the grades by 10.6 per cent in production of milk, by 9 per cent in production of butterfat, and by 14.7 per cent in income over cost of feed. The cost of feed for the purebreds, however, was $15 more a year per cow than for the grades.

Tabulations of about 35,000 yearly individual cow-feed records gave results that are very favorable to the feeding of legumes and silage. As a rule liberal feeding of grain was accompanied by high average production and high average income over cost of feed. In some districts of the West, where herds were fed liberally on alfalfa hay with a long pasture season, high average production and income over cost of feed were maintained without silage and with little or no grain.

A tabulation of the records of 5 or more unselected daughters of each of 700 dairy bulls and the records of the dams of these daughters has shown that the daughters of about one-third of the bulls produced less milk and butterfat than their dams, that the daughters of another third produced a little more than their dams, and that the remainder produced considerably more than their dams. A few of these bulls were mated with cows that averaged less than 200 pounds of butterfat a year per cow. On an average the daughters of each of these bulls excelled their dams. Other bulls of this group were mated with cows averag-

ing from 200 to 299 pounds of butterfat a year, in which case the daughters of 86 per cent of the sires excelled their dams. Of the sires mated with cows averaging from 300 to 399 pounds of butterfat per year, only 73 per cent of the sires had daughters that excelled their dams. Of those mated with cows averaging 400 to 499 pounds, the daughters of only 47 per cent excelled; of those mated with cows averaging 500 to 599 pounds, the daughters of only 40 per cent excelled. The daughters of those sires mated with cows averaging 600 pounds of butterfat or more had a lower average than their dams. Of the 700 bulls studied, only about 100 were known to be alive at the time the records of 5 daughters had demonstrated the breeding value of their sire.

PUREBRED-SIRE INTRODUCTION

As a result of a state-wide campaign in Arkansas in which 28 counties participated, 112 purebred bulls and 92 cows and heifers were placed in 1 week. A county campaign in Huntsville, Ala., resulted in the placing of 12 good purebred dairy bulls and the elimination of 10 scrub bulls. In connection with a dairy-sire special train that operated in Illinois, Indiana, Ohio, West Virginia, and Maryland, 91 purebred bulls were placed in dairy herds.

The bull-association investigational project started in Idaho in May, 1925, was discontinued June 30, 1929. The results of this study indicate that success of cooperative bull associations depends largely upon plan of organization, quality of the bulls selected, and proper supervision by officers of the association.

DIVISION OF DAIRY-MANUFACTURING INVESTIGATIONS AND INTRODUCTION

WILLIAM WHITE, *Acting Chief*

The division of dairy-manufacturing investigations and introduction was created May 1, 1929, and took over that part of the work of the dairy-introduction project that pertained to manufacturing and the introduction into creameries and factories of new and improved processes of manufacture. This report covers the work done under the old as well as under the new organization.

DAIRY MANUFACTURING

Labor studies on some creamery processes showed great variations at different plants in the amount of work done per man-hour. In operating the Babcock test the number of cream tests made per man-hour varied from 14 at one plant to 35 at another. The wrapping of 1-pound prints of butter in parchment paper, by hand, was at the rate of 240 pounds per man-hour for the slowest wrapper at one plant and at the rate of 960 pounds per man-hour for the fastest wrapper at another.

In observations made on the keeping quality of butter in 1-pound prints, it was found that samples of sweet-cream butter held for two weeks in a general-utility refrigerator, the temperature of which varied from 30° to 50° F., then stored for five months at 0° F. scored just as high as duplicate samples placed in storage at 0° F. the day the butter was made.

Butter held in bulk for two weeks at 30° to 50° F., worked nine revolutions in a single-roller churn, made into 1-pound prints, and stored at 0° F. for five months, scored an average of 1 point lower than the butter not reworked.

A study was carried on with sweet-cream butter made at three commercial creameries in Minnesota and Wisconsin. The butter was shipped in tubs to a central point, made into 1-pound prints when from 3 to 21 days old, shipped to a cold-storage plant on the west coast, and stored at 0° F. After seven months' storage samples representing 18 churnings had an average score of 92.4.

An investigation of factors influencing the quality of butter manufactured was conducted in 60 creameries in one State. A large percentage of the butter scored 90 to 91.

One-half of the creameries visited were grading cream and paying according to grade. At these plants the quality of cream received was materially better than at plants not grading.

The amount of cream containing less than 0.2 per cent acid received at plants paying a premium varied in the summer from 5 to 30 per cent of the total receipts and in the winter from 75 to 95.5 per cent. Where no premium was paid no sweet cream was received during the summer and very little during the winter.

Variation in the quality of butter at some plants was found to be due to lack of grading cream for churning. Plants maintaining uniform quality in their best butter had a definite quality standard for cream for this product and graded out all cream that failed to meet this standard.

The manufacture of 147,000 pounds of sweet-cream butter at three creameries was supervised for the Navy Department. This year the butter was stored in 1-pound prints. Samples of 18 churnings were scored after the butter had been in storage about eight months. Of these, one scored 91, eight 92, and nine 93.

The inspection of renovated-butter factories has been conducted in accordance with statutory provision. There were six licensed factories, one of which made no renovated butter. The five factories operating made approximately 3,000,000 pounds of this product, about the same quantity as was made last year. The sanitary condition of the factories was generally satisfactory.

DAIRY INTRODUCTION

BUTTER

In five Southern States the Bureau of Dairy Industry cooperated with State authorities in the introduction of proper methods of creamery operation. Educational butter scorings were held monthly or bimonthly. These scorings were conducted at the various creameries; and many of them were attended by neighboring creamerymen, who thus had an opportunity to compare their butter with that of other creameries, to learn to score butter, to make composition tests, and to discuss their problems with one another and with the dairy-manufacturing specialist.

Following are examples of losses observed in creameries in three of these States: Butter containing 85.6 per cent butterfat; butter granules in buttermilk from one churning amounting to 5 pounds of butter; nearly 10 pounds of butter sticking to the inside of a churn when the butter maker started to wash it. The elimination of such losses has resulted in saving the creameries many thousands of dollars.

CHEDDAR CHEESE

The introduction of proper methods of operating Cheddar-cheese factories was continued in Mississippi, and one trip was made to Alabama, Arkansas, Texas, Oklahoma, Missouri, Kansas, and Nebraska.

At one plant correcting the method of handling the curd in the vat resulted in increasing the receipts from the sale of cheese at the rate of $4,000 a year. At another plant the milk was not being properly pasteurized. Instruction on this point resulted in increasing the income of the plant at the rate of $9,000 a year.

At one plant the cheese on hand was of such poor quality that it was later sold for only 6 cents a pound. Several days' instruction given there resulted in the manufacture of cheese of such quality that it was sold at the Plymouth (Wis.) market price.

SWISS CHEESE

The introduction of the culture method of making Swiss cheese, which was developed in the bureau laboratories, was continued at 13 commercial plants in Ohio and 5 in New York State.

In the latter State, 386,486 pounds of Swiss cheese were made by the culture method. The percentage of cheese in each grade was as follows: Fancy, 32.88 per cent; No. 1, 55.35 per cent; No. 2, 11.77 per cent. The milk was delivered to the factories once a day during warm weather, but from November 1 to March 15 it was delivered every other day. The quality of cheese made during this period was very little below the average for the year, as shown by the following percentages of cheese in each grade: Fancy, 28 per cent; No. 1, 65 per cent; No. 2, 7 per cent.

In Ohio approximately 1,500,000 pounds of cheese were made by the culture method. This is about three-fourths of the Swiss cheese made in that State. At the Ohio State Fair, 11 culture cheeses and 6 nonculture cheeses were exhibited. All of the culture cheeses scored higher than the best of the nonculture cheeses. At the annual meeting of the Ohio Swiss Cheese Association all the culture cheeses with one exception, scored higher than the nonculture cheeses. The previous year the culture cheeses made just as good showing.

CONCENTRATED SOUR SKIM MILK

Information regarding the manufacture of concentrated sour skim milk has been furnished several plants, and cultures have been supplied by the Division of Dairy Research Laboratories to plants requesting them. Reports from plants in which this process has been introduced indicate that during the past year more than 76,000,000 pounds of skim milk were utilized in the manufacture of this product.

PUBLICATIONS AND EXHIBITS

A. B. NYSTROM, *in Charge*

Eleven new and revised publications have been issued during the year. They include 1 Technical Bulletin, 2 Department Bulletins, 1 Journal of Agricultural Research article, 2 Miscellaneous Publications, 1 Miscellaneous Circular, 3 Farmer's Bulletins, and 1 Leaflet. Twenty papers were published in scientific journals, and 24 popular articles in the Yearbook of Agriculture, 1928, and trade journals.

A list of publications of the bureau from July 1, 1924, to December 31, 1928, was compiled and mimeographed. Three monthly mimeographed circulars were prepared: The dairy-herd-improvement-association letter, the milk-inspector letter, and the milk-plant letter.

Thirty-eight lectures on dairy subjects and additional material for the weekly dairy Farm Flashes were prepared for the Radio Service. Press articles on the results of new investigations were furnished to the Press Service.

In cooperation with the office of exhibits of the department a special dairy exhibit was prepared by this bureau for the National Dairy Exposition held at Memphis, Tenn., October 13 to 20. The central feature of this exhibit was a talking cow, 6 feet high, whose stomach, intestines, udder, heart, etc., were pictured as parts of a milk factory, and the various organs, as well as their functions, were compared to similar machines in a manufacturing plant. The display also contained exhibit groups on six additional subjects.

U. S. GOVERNMENT PRINTING OFFICE: 1929

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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D. C., August 31, 1929.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1929.

Respectfully,

C. L. MARLATT,
Entomologist and Chief of Bureau.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

DECIDUOUS-FRUIT INSECT INVESTIGATIONS

Investigations of deciduous-fruit insects have been carried out under the direction of A. L. Quaintance, as formerly.

CODLING MOTH

Studies on the codling moth have been continued in the main along lines reported last year and have related especially to the spray-residue problem. Further information has been obtained concerning certain important points on the habits of the codling moth in orchards, especially the influence on the insect of climatic and other conditions. It has been found that activity of the moths in the spring is greatly retarded by cool weather, and that oviposition does not take place to any extent until the evening temperature is between 55° and 60° F. It also appears that cool temperatures during incubation of the eggs may reduce the vitality of the resulting larvæ, so that the poison used for first-brood spraying is more effective. Light winds have the effect of immobilizing the adults. Thus, in the laboratory an artificially produced 6-mile breeze directed upon adult moths resting on twigs caused them to remain there for four days without apparent movement. Further work will be necessary to determine whether the influence of winds is, perhaps, as important as that of temperature in controlling oviposition, particularly of the first brood, and what velocity of wind would be required to hold the moths quiet under natural conditions in the orchard. Along with the foregoing observations made at the Wichita station, where the work is being conducted cooperatively with the Kansas Agricultural Experiment Station, studies have been made that should help to explain variations in moth abundance in different parts of an orchard, or even on different trees in the same orchard subjected to essentially the same insecticidal treatment.

The effects of low temperatures, artificially produced, on the overwintering larvæ of the codling moth were studied during the winter of 1928–29. All temperatures were recorded by the electrothermal method by means of self-recording pyrometer and thermocouple. The lowest minimum temperature of the insect chamber from which any larvæ survived was −45° F. Some larvæ survived in various tests when the insect chamber recorded −43.5°, −41°, −29°, −26°, −18°, and −17°. One lot of larvæ was suddenly changed from a temperature of

—45° to 45°, and another lot from 42° to —29°. Three individuals survived the first treatment and two individuals the last. Such information is of value in forecasting the probable effect of winter-weather conditions in orchards on codling-moth abundance the following season.

As last year, extensive tests have been carried out in orchards with various materials to determine their value for codling-moth control and as possible substitutes for lead arsenate. Such work has been under way principally at Yakima, Wash., Wichita, Kans., and Vincennes, Ind.

At the Yakima station rather promising results were obtained with cuprocyanide, cryolite, and the fluosilicates of barium and potassium, whereas aluminum arsenate and zinc arsenate, even when used with an adhesive such as fish oil, were inferior to lead arsenate and were difficult to remove from the fruit. It was found that the use of an excessive quantity of lime with lead arsenate reduced the arsenical residue, though probably this reduced also the control value of the poison. The substitution of oil emulsion for lead arsenate in most of the cover sprays again resulted in poorer control with oil throughout. Nicotine sulphate in combination with oil or other materials showed some promise of being a useful substitute for lead arsenate. In the laboratory it was found that nicotine sulphate destroyed about 50 per cent of the eggs of the codling moth. Ten or more days is required to destroy eggs subjected to such low temperatures as are usual in cold-storage houses. Beginning with the spring of 1929, experiments were started to determine the value as a spray of oil in combination with nicotine, pyrethrum, Derris, and also with nicotine combined with various other materials. The most active principle of Derris, rotenone, is being tested, and more comprehensive tests are under way with cupro-cyanide and with certain fluosilicates. Some of this work is being done in cooperation with the Bureau of Chemistry and Soils.

At the Wichita, Kans., station many tests of materials as substitutes for lead arsenate were made in a 25-acre apple orchard. None of these materials gave results in codling-moth control equal to lead arsenate at 1½ or 2 pounds to 50 gallons of spray. Zinc arsenate gave the next best results, though these were far from satisfactory. Aluminum arsenate and calcium arsenate as well as oil sprays were of less value than zinc arsenate. The best control was obtained with lead arsenate in the proportion of 1½ pounds to 50 gallons of water, plus 1 pint of fish oil. On this plat worminess amounted to about 2.5 to 3 per cent for the season. The residue was very heavy on the fruit, but it was not difficult to remove it by wiping.

At the Vincennes, Ind., station many stomach poisons and contact insecticides were tested on a laboratory basis. Zinc meta-arsenite showed a toxicity equal to or greater than lead arsenate, but unfortunately was injurious to apple foliage. Under laboratory conditions barium fluosilicate, potassium fluosilicate, and cryolite continued to prove of value, but results were much inferior in the field. Cuprous cyanide showed a rather high toxicity, nearly equal to that of lead arsenate, but caused some spray injury when used alone. Furthermore, it is incompatible with lime-sulphur, and thus can not be used with this material, nor can it be used with Bordeaux mixture. As previously learned, casein-lime spreaders proved not to enhance the effects of lead arsenate when used at strengths greater than one-eighth pound to 50 gallons. Fish oil used as an adhesive slightly increased the efficiency of lead arsenate. Tests indicated that Bordeaux mixture and lime-sulphur impaired seriously the efficiency of lead arsenate. Certain nicotine compounds do not long retain their toxicity, perhaps not longer than one or two days after application. The addition of sodium bisulphate and aluminum sulphate to nicotine sprays, although beneficial, is attended by serious danger of spray injury. Glycerine added to free nicotine increased its efficiency and lengthened its period of usefulness. Nicotine tannate showed considerable promise. The sodium oleate-oleo-resin of pyrethrum spray, as developed at the Japanese-beetle laboratory, showed the highest toxicity of all the pyrethrum compounds tested. Its value under field conditions remains to be determined. Field tests were carried on with lead arsenate, zinc arsenate, and aluminum arsenate, all of which gave satisfactory control under the conditions of light infestation in that section. The addition of white oil or fish oil to the arsenical, or the use of oleated lead arsenate, did not seem to result in any improvement. Barium fluosilicate, potassium fluosilicate, and cryolite, used with fish oil, proved valueless, the cryolite

plat being not much better than the check. Cuprous cyanide was found to be almost as effective as lead arsenate.

Further information has been obtained on the practicability of using the chemically treated, so-called automatic, codling-moth bands. These bands, impregnated with a mixture of beta naphthol and red engine oil of paraffin base, are placed around the trunk and larger limbs of trees, and under them the larvæ spin up to pupate. They were tested in cooperation with a number of entomologists over a considerable range of territory. Four types of bands were used, namely, those made of single-faced corrugated paper, those made of crêpe paper, those made of burlap, and those made of cheesecloth. The chemically treated corrugated-paper bands appear to be the most practical, as they harbor the most larvæ, give the greatest percentage of kill, do not endanger the health of the trees, and are inexpensive. Satisfactory results were obtained with bands treated with 1 pound of beta naphthol and 1½ pints of red engine oil. It would appear that this formula may be adopted as the standard for band treatment. Some of the toxic coating may be removed by heavy rains, but it is believed that this difficulty can be satisfactorily overcome by adding a metallic soap, such as aluminum stearate, to the standard formula. Although there has been some variation in the results reported by different experimenters in the use of these chemically treated bands, the reports in general are favorable. Experience has now been sufficient to indicate their usefulness in automatically destroying the larvæ which spin up under them, usually about one-third of the larval population of the trees.

ORCHARD INSECTICIDES

Fundamental investigations of insecticides for orchard and other uses have during the past few years been arranged largely to bear on the spray-residue problem. During the year a method has been perfected for determining the minimum lethal doses of dry powdered stomach-poison insecticides for a laboratory-test insect, the silkworm. This so-called "sandwich method," which will be described in Anzeiger für Schädlingskunde, has been used to determine the absolute toxicity of a number of stomach poisons, including acid lead arsenate (used as the standard of comparison), basic lead arsenate, aluminum arsenate, manganese arsenate, copper cyanide, copper thiocyanate, various fluosilicates, potassium iodate, calcium iodate, potassium periodate, nicotine tannate, diphenyl, and rotenone. This method of determining the lethal quantities of poison will be used in the bureau's cooperative work with the Bureau of Chemistry and Soils in the development of new insecticides, especially the derivatives of rotenone, various synthetic compounds similar to nicotine tannate, pure nonlead arsenicals, etc. Attention is being given to the toxicity of stomach poisons administered directly through the mouth to newly hatched codling-moth larvæ by means of a micromanipulator. The absorption, distribution, and elimination of lead in insects is being investigated by the radioactive-indicator method.

Improvements are being made in methods for determining the relative toxicity and intimate action of contact insecticides. It appears that the immersion of aphids in solutions yields dependable results. By a study of the rate of recovery of the insects and of the speed of lethal action, it has been possible to determine with an indicator and to differentiate the effects of closely related materials. The relative lethal persistence of various preparations, such as nicotine, rotenone, and pyrethrum, on different surfaces is being given attention. Newly hatched codling-moth larvæ are made to crawl across these surfaces at various intervals of time after the spray has dried.

The insecticide-information service has been maintained and strengthened and a large up-to-date bibliography on insecticidal materials throughout the world is available. It consists of about 20,500 cards, representing about 17,000 distinct references. Effort is being made to keep this bibliography up to date, and it is being utilized in the preparation of papers on various insecticides. The first paper of the series is now being prepared and will cover the halogen derivatives of benzene, paradichlorobenzene being the most important compound of the group.

PEACH INSECTS

As in former years, extensive orchard tests have been made at the Fort Valley, Ga., laboratory of various spray and dust formulas for the control of the plum curculio under southeastern conditions. The infestation by this insect during 1929 in Georgia, and in the South generally, has been the heaviest since 1921. This has resulted

in part from the large quantity of wormy fruit left in orchards in 1928, and in part from the mild winter of 1928–29. Furthermore, the insect was able to get a fairly early start this spring, and there has been time for development of a very considerable second brood. In addition to experiments designed to determine the control value of various dusting and spraying combinations and times of application, attention has been given to tests of different types of spraying and dusting apparatus.

Attention has been given to ways and means of preventing, if possible, arsenical injury to peach foliage. Ferric oxide and lead acetate were found to be most valuable for reduction of this burning, although some foliage injury resulted when the latter chemical was used. Various fluosilicates have been under test as substitutes for lead arsenate, especially to determine their effect on peach foliage. Of those tested, potassium fluosilicate in the proportion of 2 pounds to 50 gallons of water caused less injury to the foliage than did lead arsenate. Under field conditions, however, the use of this material as indicated was followed by defoliation of trees due to bacterial leaf spot, and the work was abandoned.

The lesser peach borer, which infests the trunk and larger limbs and crotches of the peach, has been the subject of special experiment in view of its prevalence and damage to peach orchards in the Southeast. It was found that when paradichlorobenzene dissolved in cottonseed oil was applied with a brush to the infested areas the larvæ were quickly killed without injury to the trees. Although further studies will be made with this treatment, it is now felt that it is safe to recommend it for general use. The employment of this material in paint form will prove useful, it is believed, against various other insects of similar habits.

The oriental peach moth did its first commercial damage to peaches in the southern Indiana section during the season of 1928. Here some of the late varieties were almost 100 per cent infested. The experimental work undertaken in the spring of 1929 involved considerable testing in orchards of various sprays and dusts, especially heavy applications of lime and talc, the use of which, according to some investigators, interferes with the successful oviposition of the moths or the movements of the larvæ on the trees. At the Vincennes, Ind., laboratory work is being done on the use of bait traps, repellent materials, the determination of the parasite fauna of the peach moth, banding, and studies of the overwintering habits of the larvæ. Special investigation of the parasites of the peach moth, however, is centered at the Moorestown, N. J., laboratory. In addition to studies of local parasites, material is being obtained from as much of the infested region in this country as possible in order to determine what native species are attacking this insect as it spreads into new regions. Although the home of the peach moth is not definitely known, the insect has been present for some years in different localities in Europe and has been recorded from Australia. On account of the difficulty of controlling the peach moth by the usual spraying methods, the utilization of parasites becomes extremely important, and foreign countries should be thoroughly searched for these with as little delay as possible.

NUT INSECTS

Work on nut-infesting insects is divided into two distinct projects, namely, insects affecting the pecan, and those affecting chestnut, walnut, etc. Headquarters for the latter project are at French Creek, W. Va.

The rapid disappearance over wide areas of the native American chestnut, due to the chestnut-blight disease, has led to an interest in extensive plantings of the more or less blight-proof species of chestnuts from Japan and China. This program is seriously hampered by the prevalence of nut weevils, which destroy American-grown nuts for seed, and nuts grown in orchards for home and market purposes. Investigations have been made in a considerable number of orchards of Japanese and Chinese chestnuts to determine conditions which bear upon loss from these weevils. Experiments with various arsenical sprays and dusts have, unfortunately, shown no beneficial results. Tests are under way to determine the value of picking up all nuts as fast as they ripen and so handling the crop that weevils will not be able to escape and enter the soil. It is hoped that by this method chestnut growers, by exercising vigilance, will be able to effect a reduction of this pest so that a reasonable crop of sound nuts can be secured. In connection with the biologic studies, information is being obtained on the natural enemies of nut weevils in the hope that means may be found for their more effective use. Experiments to determine the effect of orchard cultivation on the insects undergoing

transformation in the soil have shown but little benefit thus far, owing to the considerable depth to which the grubs of these weevils penetrate for pupation. Tests with soil fumigants have been made, but must be repeated before conclusions can be announced.

Investigations of pecan insects in the South were continued in the main along lines under way the preceding fiscal year. The principal laboratory is at Albany, Ga., and there are three sublaboratories situated in districts where special investigations can be most advantageously pursued. Thus, one is located at Brownwood, Tex., for a study of insects destructive to native as well as cultivated pecans; another, recently established at Shreveport, La., will concern itself with pecan insects injurious in that general section; still another, at Experiment, Ga., is giving special attention to certains pecan borers and the nut weevil.

At Albany, Ga., a comparison was made of the methods of applying poison dusts against the pecan leaf case bearer by airplane and by ground machines. In the applications by airplane cooperation was obtained from the cotton-insect division of the bureau and from the Bureau of Plant Industry. Five applications to a sizable pecan grove were made for the simultaneous control of pecan scab and the leaf case bearer. The flying was done at a speed of from 95 to 100 miles per hour. The swath widths averaged about 47 feet or approximately the distance between the tree rows. Four airplane loads, or 2,000 pounds of dust, were applied in each dusting, making an average of about 3.8 pounds of dust per tree, or 76 pounds per acre. The dust cloud discharged from the plane used in the tests followed a spiral course and showed a decided tendency to rise and remain above the trees for some distance beyond the path of flight of the plane. Gradually, however, it settled, some six or more rows away. A careful check on the results of this dusting as determined by the abundance of the insect on treated and untreated trees indicated no appreciable difference between the results with poison applied by airplane and those with poison applied by ground machines. Until opportunity is afforded for conducting additional experiments with the airplane in pecan dusting it is felt that no recommendations from the insect-control standpoint are justified.

Extensive tests were made against the pecan leaf case bearer by dusting with ground machines to determine the best materials and the best times to make applications to obtain maximum control. Work was done on some five or six different properties. Best results were obtained from two applications of dust composed of monohydrated copper sulphate 20 per cent, lead arsenate 10 per cent, and hydrated lime 70 per cent. In a comparison of homemade and factory-mixed dusts the latter gave the better control. Aluminum sulphate, when used with lead arsenate, showed no superiority to monohydrated copper sulphate. Very good results were obtained with Paris green used with monohydrated copper sulphate and hydrated lime, and there was no injury to the foliage of the plant. Calcium arsenate gives promise of being a suitable insecticide for the pecan, and used at proper strength it did not endanger the foliage.

In addition to the field work under way at Albany, Ga., a good deal of time has been devoted to biologic studies, particularly of the hickory shuck worm, which is attracting more and more attention on account of its injuries. Local damage by Phylloxera in pecan nursery trees has necessitated observations on this insect, which will be seriously studied at the first opportunity. Work has been started looking toward the utilization of parasites of pecan insects, in view of the difficulty in general of insect control on trees of such large size as the pecan. Parasites have been reared from most of the common species and information concerning these is being obtained.

At the sublaboratory at Experiment, Ga. (recently transferred there from Barnesville, Ga.), attention has been given especially to the life history and habits of the pecan weevil, which in that general section is quite injurious. Studies on its life cycle have been pretty well completed, and observations have been made concerning the behavior of the larvæ in the soil, as well as on the time of appearance of the adults on the trees. Experiments are under way to determine the effect on the grubs and the immature adults in their cells in the earth of soil cultivation and of soil fumigation. The possibility of killing the adults with arsenical sprays or dusts has been investigated, but no treatment of special promise has thus far been found.

At the Brownwood (Tex.) sublaboratory, in addition to considerable experimental work with dusts and sprays for the control of the pecan-nut case

bearer, the staff is specializing on the parasites of the more important pecan insects of that district, in view of the impracticability of the use of artificial means of control on large, wild pecan trees growing in the river bottoms and elsewhere, from which so large a part of the Texas crop is produced. Cultures are being made of the egg parasite *Trichogramma minutum* Riley for use against the nut case-bearer and other species.

The assistant at the laboratory established about January 1 at Shreveport, La., has spent most of the spring in survey work in order to become familiar with the more important pecan insect pests of that district. Injuries here by certain species of May beetles and by the pecan shuck worm have been investigated and biologic and experimental control work undertaken.

BLUEBERRY MAGGOT

There has been little change in the general situation with regard to the blueberry-maggot problem in eastern Maine since last year. Growers who cooperated in the bureau's experimental dusting involving considerable areas of blueberry barrens were pleased with results and have equipped themselves with machinery and materials for effective control work. Experiments continue to show the efficiency in blueberry-maggot control of calcium arsenate dusted over the plants. One application of dust in early July effected a reduction in maggots of 62.69 per cent, and two applications a reduction of 89.6 per cent, as compared with the number in the untreated check plat. The topography of the blueberry barrens is such that the question arose as to whether dust could be economically applied by means of the airplane. Under special provision by Congress applications of dust by airplane were made by a commercial firm in July. An average of 6.61 pounds of dust per acre per application was made to most plats. The average benefit from all plats receiving two applications was a reduction of 82.86 per cent in the number of maggots. The cost of the application of dust by airplane greatly exceeded that by ground machines, but this cost would be reduced if the area treated were enlarged.

Considerable time has been given to obtaining as full information as possible concerning the biology, habits, and ecology of this insect, which in reality is the common apple maggot, and it is believed that another season's work will permit of the preparation of a complete report on the subject with practical recommendations for its effective and economical control.

GRAPE INSECTS

Work on grape insects at the Sandusky (Ohio) laboratory has been limited to vineyard experiments to develop a spray schedule which will obviate arsenical-spray residues on the harvested fruit. The necessity for late spraying is due largely to damage in midsummer and later by the grapeberry moth, which in the northern Ohio district is very injurious. Much of this work has paralleled activities with a similar objective on apple. Many possible substitutes for lead arsenate have been tested under vineyard conditions, including many arsenicals, fluosilicates, various plant extracts, and the like, but none have proved equal to lead arsenate. In cooperation with the officials of the Bureau of Chemistry and Soils at Cincinnati, Ohio, detailed information has been obtained on the quantity of poison present on harvested fruit following application of various poisons. Unfortunately, in the experimental-vineyard blocks where control of the second brood of the grape berry moth has been secured, the ripening fruit has in a majority of instances shown arsenic in amounts considerably greater than 0.01 grain per pound of fruit, some samples running as high as 0.07 grain per pound or above. Vineyardists are therefore forced to confine applications to the first brood of berry-moth larvæ. In heavily infested vineyards this has resulted in serious loss. Very thorough spraying against the first brood, followed by applications of nonarsenical materials for the second brood, obviates the residue difficulty, but control of the insect has not been entirely satisfactory. Further attention will be given to this situation, and it is hoped that unobjectionable and effective sprays can be developed for the benefit of grape growers.

JAPANESE AND ASIATIC BEETLES

In the heavily infested district damage by the Japanese beetle was as severe as in previous years and was somewhat more widespread. Ornamental plants were severely damaged in the suburbs of Philadelphia and Trenton, and in Camden and Gloucester Counties, N. J. Field and sweet corn suffered in New Jersey and Pennsylvania, especially the so-called second planting of field corn in Bucks County, Pa. Thorough and timely

spraying with lead arsenate continued to give excellent protection on plants on which this material could be used. The protection of early ripening varieties of peaches and small fruit and of flowering shrubs must be studied further before recommendations can be made.

Several phases of the biologic and physiologic studies under way have been completed, and results have been prepared for publication. The great importance of a treatment for grubs in the soil necessitated the study of the physiological resistance of the immature stages throughout the year. This work has been completed, and the results have been used as a basis for determining the dosage of soil insecticides required by quarantine regulations at different seasons to obtain most effective destruction of the larvæ. Studies are being made on the effect on the grubs of the Japanese and Asiatic beetles of sublethal dosages of various insecticides, and also on the effect of submergence in water for various periods of time—information needed primarily in connection with treatments required by quarantine regulations. Attention is being given to the relation of local conditions, climate, etc., to the Japanese beetle. With its spread into other districts, such as Virginia, Massachusetts, and points in Maryland, these ecological studies become important and will take account of the influence on the insect of crop conditions and practices as affecting its food supply, and of soils and other factors.

In connection with investigations to develop insecticides for the protection of peaches and other early ripening fruits, thoroughgoing studies of repellent materials have been undertaken. In the course of this work a large number of compounds have been under test, and the results thus far indicate that coal tar, creosote, empyreumatic oils, phenyls, and the cyclic nitrogen compounds have repellent properties, whereas esters, ketones, ethers, aldehydes, and essential oils are likely to be attractive.

The difficulty encountered during the past few years in the manufacture of oleate-coated lead arsenate was due in part to the lack of accurate methods for determining the proportion of lead oleate present. It is believed that this difficulty will be overcome. Manufacturers should then be able to standardize their product to a greater degree than heretofore. A spray that is useful in controlling large numbers of the Japanese beetle has been developed, namely, a combination of lead arsenate and highly refined sugar sirup. Such a spray can be used very effectively on noneconomic plants when the beetle population is dense. In studies of extracts of pyrethrum it has been found that the most satisfactory extracts are obtained with pyridine, acetone, and isopropyl alcohol, and that Derris is most effective when it is extracted with coal tar, naphtha, or ethyl alcohol. Tests show that extracts of pyrethrum and of Derris are about equally effective on the beetle. Experiments indicate the control of the insect on corn by the use of a dust composed of 9 parts of hydrated lime and 1 part of powdered lead arsenate, applied early in the morning when the dew is still present on the plants.

Following much experimentation, a new type of Japanese beetle trap has been designed which has very high efficiency in capturing the insects. The principle involved will render the traps much more effective than they have been heretofore. In this connection extensive studies have been made with various types of bait in the traps, and distinct improvements have been made.

Investigational work with hot water used as a dip to destroy immature stages of the Japanese beetle has been about completed. The immersion of the roots of certain types of nursery plants for a short period has been found a simple and effective method of destroying grubs in root cavities and masses of soil. The treatment consists in heating the soil about the roots to a temperature of 112° F. and maintaining this temperature for 70 minutes. This treatment has been applied to several varieties of herbaceous plants as well as deciduous shrubs and will be of special interest to nurserymen in the infested districts.

Experiments indicate the effectiveness of naphthalene as a soil fumigant of potting soil for the destruction of the immature stages. When naphthalene flakes are used at the rate of 5 pounds, thoroughly mixed in a cubic yard of soil and left undisturbed for a week, all stages of the Japanese beetle are killed.

Extensive experiments have been conducted during the year to determine the effectiveness of lead arsenate as a soil insecticide. It appears from preliminary work that a large number of varieties of evergreens, deciduous trees, and shrubs, as well as other nursery stock, will grow in soil treated with sufficient lead arsenate to pre-

vent beetle development, and without injury to the plants. This extension of the use of lead arsenate has followed considerable experience in the destruction of grubs in lawns and golf courses, where it is used in the proportion of 5 pounds to each 1,000 square feet of turf.

Gratifying advance has been made in the establishment of parasites of the Japanese and Asiatic beetles, some 337,000 having been received during the year from bureau employees located in India and Japan. Five or six species have become well established. Some of these have spread noticeably, and their colonies have become sufficiently strong to permit the making of collections for liberation in other localities. Thus from the original colony of *Tiphia popilliavora* Rohwer, at present the most promising parasite introduced, it has been possible to collect enough of the insects to establish 25 colonies, the insects being released mostly in the suburban area around Philadelphia. It is believed that some 200 new colonies of this species can be established during the season of 1929. Four colonies of *Tiphia vernalis* Rohwer are now established in Pennsylvania and New Jersey. Additional work is being carried on with several parasites which have not as yet been established in this country. It is believed that further work will enable the department to establish several additional species in the infested area. Special effort is being made to bring in as large numbers as possible of the parasites already established in order that as many colonies as possible may be liberated throughout the range of the Japanese beetle.

Under appropriations available July 1, 1928, a thoroughgoing study has been undertaken of the freeing of plants and plant products from infestation by insects. In connection with this work a check on various methods now used in connection with State and Federal quarantine regulations is being made to determine their effectiveness, both from the standpoint of killing the insects and from that of their effects on the plants. Extensive search of literature has been made and a manuscript on methods of freeing plants from insect infestation has been prepared for publication. This will be especially useful as a working handbook for those concerned with quarantine matters. Studies have been already inaugurated to determine the effectiveness of hot water, naphthalene, carbon disulphide, and 25-meter high-frequency radio waves in destroying infestations of various insect pests on several agricultural commodities. It is hoped that during the course of this work new methods and improvements may be developed suitable for a wide range of products, especially nursery stock and imported food products now subject to regulation as to injurious insects and diseases.

CEREAL AND FORAGE INSECT INVESTIGATIONS

The work on insects affecting cereal and forage crops has been, as formerly, under the direction of W. H. Larrimer.

EUROPEAN CORN-BORER RESEARCH

The enforcement of quarantines against the European corn borer and related regulatory and control activities have, since July 1, 1928, been conducted by the Plant Quarantine and Control Administration of this department while the research activities have been carried on, as before, by the Bureau of Entomology. The European corn borer has continued to spread in the Great Lakes area at about the usual rate. In Ohio and Indiana this movement apparently was less extensive in 1928 than was the case during the previous year, owing no doubt to the intensive and thorough scouting campaign conducted in 1927, which resulted in determining the actual border of the infestation in these States. The commercial damage to the crop resulting from the work of the pest still remains small or almost negligible. Recent infestation counts, however, show unmistakably that the insect has multiplied rapidly during the last year in Ohio, Michigan, and Indiana.

The work of parasite introduction has progressed rapidly and satisfactorily in recent months, and more than 1,000,000 additional parasites, comprising nine species, were liberated, principally in the States of the Middle West, since my last report. In New England, where the introduction work has now been in progress for only 10 years, no less than nine species of introduced parasites have been recovered, several of them in considerable numbers. In this connection it should be understood that, owing to the differences in the biology of the various species, some of them multiply readily under laboratory conditions whereas others must be liberated directly without any attempt at artificial breeding. Two species of the latter class, namely, *Masicera senilis* Rond., a tachinid or fly parasite, and *Dioctes punctoria*

Roman, a hymenopterous or wasplike parasite, have now become so numerous in Massachusetts that it is expected collections can be made there in the season of 1930 for reshipment to the infested area of the Great Lakes.

In June, 1928, a competent investigator was dispatched to Japan to collect and ship to this country any useful parasites of the corn borer that might be found there and on the Asiatic mainland. The corn borer was found in practically all of Japan from Hokkaido or Yezo on the north to Formosa on the south, as well as on the mainland in the Chosen Peninsula. From this general territory five species of parasites have been collected, identified, and introduced, two of which are believed to be distinct from any of those yet found in Europe. Other species have been found in Japan that have not as yet been identified. To take adequate advantage of the prevalence of parasites in the Orient, preparations are being made to dispatch an assistant to Japan to facilitate the more rapid introduction of these beneficial insects.

In the sweet-corn-growing sections of eastern New England successful efforts have been made in recent years to lengthen the market period for the finer varieties of this vegetable by placing the ears of corn in cold storage at freezing temperatures. In this connection our investigators were called upon to determine the effect on the corn borer of the temperatures used for refrigeration in order that data as a basis for quarantine action might be available. It was determined that when the corn was kept at or near 0° F. the borers contained in it rapidly succumbed and all of the borers died after the lapse of 100 hours. This was not true of seed corn, however, in the ears of which borers frequently hibernate.

Especially significant have been the results obtained in the operation of two emergence cages, each 1 acre in extent, on the experimental farm at Toledo, Ohio, devoted to training of scouts, the development of agricultural machinery for corn-borer control, and the many phases of corn-borer research. These cages were erected immediately previous to the expected emergence of the corn-borer moths on fields in which the borer population was known, and which had been treated by approved cultural control methods such as plowing cleanly either in spring or fall. The results showed in both cases that the methods employed had killed over 98 per cent of the borers. Although these results confirm the general results obtained during the recent clean-up campaign, it is planned to repeat the experiments to eliminate any possible error.

ALFALFA WEEVIL

The alfalfa weevil continues slowly to spread toward the Mississippi Basin and is now firmly established in western Nebraska. It has just been discovered at Medford, Oreg., near the Pacific coast, only 25 miles from the northern border of California on the main line of a railroad running into that State. It seems inevitable that this pest eventually will make its way into all the principal alfalfa-growing regions of the West.

The investigation of the manufacture of alfalfa meal as a possible means of distributing the weevil, which was begun last year, is now nearing completion. The results show that when the manufacture of this commodity is conducted with proper precautions the danger of distributing the pest through commerce in the meal is very slight if not negligible. It was discovered, however, in the course of the investigations that more than one-half of 130 freight cars examined, which had contained alfalfa hay from infested regions, were infested with alfalfa weevils. It was apparent also that the weevils might remain in such cars almost indefinitely and thus be carried to almost all parts of the United States. Some of the cars investigated were traced to New York, Omaha, Portland, and Los Angeles.

There has long been a question in the minds of certain ranchers of the Great Basin whether alfalfa hay which had been sprayed with arsenicals to kill the weevil is in any way hurtful to cattle. Preparations are now under way to investigate this matter thoroughly.

LEAF HOPPERS AND ALFALFA

For some time there has been a growing suspicion among entomologists and agronomists that an abnormal and harmful condition in alfalfa commonly called "yellows" was caused by the feeding of leaf hoppers. A preliminary survey of the matter conducted by the Bureau of Plant Industry resulted in reinforcing the idea that the insects were acting as vectors of a disease, and that bureau therefore appealed to the Bureau of Entomology for aid in making a thorough investigation. A qualified entomologist was assigned to the

study of the entomological phases of the problem at Arlington, Va., beginning in April, 1928. His preliminary findings, which have just been announced, indicate that this yellowing of the alfalfa is caused principally by the feeding of a common and widely distributed leaf hopper, *Empoasca fabae* Harris. It is planned, however, to go more thoroughly into this problem in order to bring about the control or elimination of this widespread injury as well as to determine whether other factors may be concerned in the matter.

PEA APHID IN ALFALFA

Damage to alfalfa by the pea aphid and related species has been increasing for several years. The losses from this cause have been especially severe in the irrigated lands of California, Nevada, and Idaho, but a similar condition is known to exist in several States of the Great Plains where alfalfa is the principal forage crop produced. In the Antelope Valley of California losses have been especially severe, and the time of an entomologist attached to this division has been devoted principally to an investigation of this problem. Many methods of control have been tried, including dusting both from the surface and from airplanes, the burning over of infested fields with motorized burners of special design, and the practice of cultural methods based on cutting the crop at various times and handling the irrigation water in different ways. None of these methods have yet proved satisfactory.

HESSIAN FLY

The Hessian-fly situation in general remains most satisfactory from the standpoint of wheat growers. The insect is reported as at the lowest ebb of abundance that has occurred for several years in Kansas, and it is scarce in the northern half of the East Central States. A moderately severe infestation exists in southwestern Indiana, where much early sowing of wheat has been practiced recently.

A continuous record of outbreaks of this pest, kept for about 50 years in the East Central States, shows that up to 1919 there occurred more or less regularly, at intervals of from six to eight years, severe general outbreaks which usually took a heavy toll of the wheat crops. Since then, however, no such great invasion has been recorded, and it seems fair to assume that this is due in large measure, if not exclusively, to the general adoption of the control measures advocated by the department and supported by the State agricultural authorities, wherever winter wheat is grown as the main cereal crop. This general-control program, however, is made possible only by the annual regional surveys conducted by the bureau, the results of which are communicated to the various States concerned.

GRASSHOPPERS

Indications point to impending outbreaks of grasshoppers in North Dakota and many counties in Texas. The grasshopper population in the northern section of the Great Plains area has gradually increased during the last three years, until in the fall of 1928 a survey in western North Dakota indicated strongly the imminence of a general outbreak this year in that section. In an effort to prevent this invasion the bureau assigned one of its experts from the Billings, Mont., field laboratory to cooperate with the State experiment station by preparing and distributing a special publication on the control of the pest in the area affected. This was issued as Special Circular No. 1 of the North Dakota Experiment Station in March of this year.

The Texas outbreak developed rapidly during the spring of 1929 until some 17 counties were affected, extending from Matagorda along the Gulf on the south to Collin, Archer, and Motley Counties on the north and west. At this writing the staff located at the San Antonio field laboratory is cooperating in a survey of the situation.

In California during the summer of 1928 about 2,000 acres of grain were destroyed by grasshoppers in Siskiyou and Modoc Counties. This situation has been greatly improved, however, by the general use of the poisoned baits.

SUNFLOWER INSECTS

In recent years there has sprung up in eastern Missouri a rather lucrative industry, the production of sunflower seed as food for poultry. As the acreage increased in this district, the usual multiplication of insect enemies developed until an appeal for aid was made by the growers to the bureau through its local representative at Webster Groves, Mo. In compliance with this request an investigation was begun, with the result that much valuable information regarding the insect fauna of this plant has been accumu-

lated. It is planned to publish these results in the near future.

In the course of this investigation an egg parasite of snout beetles of the genus Calendra was reared in considerable numbers, and this fact was brought to the attention of a representative of the Hawaiian Sugar Planters' Association who was in this country in search of parasites for introduction there against the sugarcane borer. At his request a supply of this parasite, *Anaphoidea calendrae* Gahan, was reared and turned over to him for shipment to Hawaii.

MORMON CRICKET

As a result of the serious situation caused by the invasion of the Mormon cricket originating on public lands in Routt and Moffatt Counties in northwestern Colorado, the last session of the seventieth Congress appropriated $8,000 to be expended for the purchase of materials and poisons to combat the pest. It was understood that the farmers would furnish the necessary labor and that the State would supervise the work. The campaign is now in full swing, but it is too early to report results.

RANGE CATERPILLAR

The outbreak of the range caterpillar mentioned in last year's report is now under way in northeastern New Mexico. Owing to the cold, backward spring of the present year, the eggs did not begin to hatch until late in June, but recent reports show that a very heavy infestation is in progress and that serious damage to a million or more acres of the finest cattle ranges in the Southwest is almost certain. A trained entomologist has been stationed there temporarily to assist in introducing beneficial insect enemies and to obtain general information on the outbreak.

INTRODUCTION OF PARASITES OF THE SUGARCANE MOTH BORER

To supplement the effort at control of the sugarcane moth borer in the Gulf States by mechanical and cultural means, the introduction of insect enemies of this pest from the West Indies was undertaken some years ago. It was found, however, that the parasites occurring there apparently were not effective when removed to this country, and it was therefore decided to seek more effective parasites in South America, where climatic and cultural conditions more comparable to those occurring in the United States were known to prevail. Accordingly, an expert was dispatched in the summer of 1928 to Argentina and headquarters established at Tucuman. Since that time four species of parasites have been discovered, shipped to New Orleans, and there liberated. Apparently the most promising and abundant of these is a sarcophagid fly which is believed to be specific to the moth borer.

INVESTIGATIONS OF INSECTS AFFECTING STORED PRODUCTS

E. A. Back has directed the investigations of stored-product insects, as in previous years.

INSECTS ATTACKING GRAIN AND GRAIN PRODUCTS

An outstanding feature of the work with insects attacking stored grain and grain products has been a continuation of the investigation of insects affecting flour begun at the close of the previous fiscal year. The data obtained during the year have had to do with control in flour mills and flour warehouses, with special regard for the conditions affecting successful treatment of sacked and cartoned materials. They indicate that there is great need for a more thorough attack upon this problem than has been possible heretofore.

The field-control work directed against the weevils attacking stored corn throughout the South has continued to give gratifying results. It has further emphasized the importance of insect control in storage as a prime requisite in the production of a corn crop that will carry with it into storage a minimum of infestation. In many fields of corn growing near farm buildings, in which no attempt had been made to eliminate weevils, nearly all ears were found infested at time of harvest. In other fields of corn growing close to storage places in which systematic protection of the corn by fumigation had been practiced, or in fields distant from storage places, it was difficult to discover weevils at harvest time. This work seems to indicate (1) that if no weevils are allowed to leave bins or cribs where grain is stored, there will be no field infestation; (2) that weevils in large numbers do not fly great distances from the source of infestation; (3) that two fumigations a year, when properly done, will keep stored corn free of weevils; (4) that weevils

are being successfully and economically controlled by fumigation; and (5) that there is no insect in the South as destructive to farm wealth which can be more easily controlled.

DRIED-FRUIT INSECTS

The major activity in the project relating to insects infesting dried fruits has been the investigation of the biology and control of the dried-fruit beetle and other fig-infesting species. A survey of the insect population of fig orchards in the principal producing areas of central California was made through the use of a new type of trap and by the examination of a large series of samples of figs. Tests were made of the effectiveness of trapping for the control of the dried-fruit beetle and its allies. Trapping was only partially effective in controlling these insects and the diseases of which they are believed to be the chief vectors. The bait used—a slowly fermenting mass of cull dried peaches—was very attractive to the beetles, but did not compete successfully with the attraction offered by ripening figs. A search for more attractive baits has proved unproductive. The attractiveness of the peach bait, however, was found to be increased by allowing it to become infested with larvæ of the dried-fruit beetle.

Much new information regarding the life history of the dried-fruit beetle was obtained and offered for publication.

A survey was made of the condition of dried figs in about 75 per cent of the tonnage of all growers' deliveries at packing houses. The data obtained have been made available to fig growers through personal contacts, growers' meetings in the field, and the annual fig institute, with the result that an increased understanding of the fig-insect problem has been promoted and fumigation equipment at the plants of small fig packers considerably increased.

Experiments with fumigants for the control of dried-fruit pests, especially with reference to raisins and figs, were continued. These have included work with hydrocyanic-acid gas, isopropyl formate, ethyl formate, ethylene oxide, a mixture of carbon disulphide and carbon dioxide, and several proprietary products. Attention was given to adapting ethylene-oxide fumigation to the needs of the dried-fruit industry. Tests already completed, both in fumigation chambers and in refrigerator cars loaded with packed raisins, have given encouraging results.

The widespread occurrence of the Indian-meal moth and the fig moth in new-crop raisins was investigated. It was found that these infestations are largely the result of improper storage methods on the ranches and can be eliminated almost entirely by the grower himself by the application of known remedial measures.

FUMIGANTS

The work of developing new fumigants and of adapting them to commercial practice has been continued throughout the year.

A noteworthy development has been the discovery of a new principle in fumigation. It has been found that the lethal effect of the combination of certain gases upon insects is far greater than the effect of either one used alone. A preliminary paper on the use of carbon dioxide to increase the insecticidal efficacy of fumigants has already been published and deals with one phase of the new principle. The use of carbon dioxide in combination with other fumigants reduces the length of exposure needed to kill insects in infested products to one-third or even one-fourth of the time normally necessary without carbon dioxide, and this method gives perfect results when only about half the usual quantity of the fumigant is used. It is particularly adapted for vacuum-fumigation tests, but is also applicable for use in ordinary gas-tight vaults. Experimental work upon other phases of this principle is being completed and will be reported upon shortly.

In the early part of the fiscal year a paper was published regarding a new fumigant, ethylene oxide, developed in cooperative work between this division and the Bureau of Chemistry and Soils. Subsequent work with this fumigant has shown that it is the best gas now available for use in treating foodstuffs. It is safe to use, noninjurious to foodstuffs, leaves no odor or poisonous residue, and is very effective in killing insects. Considerable time has been devoted to determining the best methods of using this gas in the fumigation of different types of commodities, dosage tables have been worked out, and all available information regarding it has been incorporated in a paper that has been submitted for publication. Special attention has been paid to the fumigation of nut meats, which are extremely

difficult to treat successfully. Owing to the fact that nut meats absorb tremendous quantities of fumigants, special dosage schedules have had to be worked out for both atmospheric and vacuum fumigation.

Several promising new fumigants are being tested and will be reported upon shortly.

BEAN WEEVILS

During the year the large-scale experiments for the control of bean weevils in California, undertaken with the establishment of the Modesto laboratory, have been continued. This work has been made possible only by the hearty support and cooperation of the State, county, and Federal agricultural organizations operating in Merced, Stanislaus, and San Joaquin Counties. A feature of the year has been an unusually heavy infestation by the southern cowpea weevil in the section where black-eyed cowpeas are grown, and of baby limas by the common bean weevil. Notwithstanding these adverse developments, bean growers and bean warehousemen are enthusiastic over the very noticeable decrease in cash deductions made because of weevil infestation in the bean crop as a whole.

The excellent spirit of cooperation shown by growers and warehousemen has made possible, through the examination of thousands of samples taken at the time farmers deliver their crop at the storage houses, the detection and prompt reporting of evidences of infestation. Where infestation has been discovered the entire consignment of beans has been fumigated before it has been allowed storage space in the warehouse, and a thorough study has been made of conditions in and about farm buildings and fields of the farmer producing the weevily crop. By this procedure valuable facts are being obtained concerning farm conditions favorable to the production of weevily crops.

HOUSEHOLD INSECTS

Insects destructive to house furnishings, whether these are in the home or warehouse, have received as much attention during the year as limited funds have permitted. The interest of housewives, furniture manufacturers and retailers, and furniture warehousemen has continued to be much in evidence. As a result the study of conditions encouraging to the development of clothes moths, carpet beetles, and tow bugs has been continued. Special attention has been given to methods of control suitable for the housewife, retailer, and warehouseman. There has been a great increase during the year in the equipment installed by private firms for protection against this group of pests. Experiments with solutions for the protection of fabrics against the attack of fabric pests have been continued, but to date no so-called moth-proofing solution tested has rendered fabrics absolutely immune to attack.

INVESTIGATIONS OF TROPICAL, SUBTROPICAL, AND ORNAMENTAL-PLANT INSECTS

Investigations of insects injurious to tropical, subtropical, and ornamental plants have been conducted, as formerly, under the direction of A. C. Baker.

MEDITERRANEAN FRUIT-FLY RESEARCH

The most important work of the division during the year has had to do with the presence of the Mediterranean fruit fly in Florida. Immediately on the discovery of the fly the laboratory at Orlando, Fla., diverted every energy to research on the insect, and the fruit-fly laboratories in Hawaii and Mexico were called upon for assistance.

The research in Florida has been shaped on the following plan, the work being conducted under the Plant Quarantine and Control Administration: (1) The development of effective sprays for the adult flies, and a check up of these sprays as they are applied in the eradication campaign, the check-up being concerned both with the chemical nature of the materials under large-scale operations and the effect of the sprays on the trees; (2) the development of attractants for the adults and the use of these attractants in traps throughout the infested territory, thus making it possible to follow the rise and fall of the fruit-fly populations, both in relation to the application of sprays in this territory and in relation to the elimination of hosts; (3) a quantitative survey of the wild fruiting plants in the infested territory to determine the facts and possibilities of spread of the fruit fly into uncultivated areas; (4) a similar survey of cultivated fruiting plants to determine the hazards from the presence of cultivated plants not exposed to attack by the fly in other countries; (5) experiments under caged condi-

tions to determine what wild or cultivated fruits the fly will accept for oviposition if deprived of other host material; and (6) the development of methods of treatment which will guarantee susceptible fruits against the possibility of introducing infestation into other parts of the country.

The following results have been obtained: A spray formula has been developed which has proved exceedingly efficient in the eradication operations. Since the poison contained therein is lead arsenate, and since arsenicals are considered somewhat injurious to citrus trees, a substitute has been sought for. In accordance with a new theory, poison compounds have been prepared. The cooperation of the insecticide division of the Bureau of Chemistry and Soils is acknowledged in the preparation of certain of these compounds on request. The compounds prepared have proved more highly toxic to the fly than lead arsenate, and in the standard fruit-fly formula have been sprayed upon the same foliage for 37 successive days without apparent injury to trees or foliage.

Many reports of injury by arsenical spray have come to the laboratory, and these have been investigated. In every case reported to date the injury has been assignable to causes other than the spray. Very often the trees have been in a weakened condition because of attack by scale insects, lack of fertilization, or similar circumstance.

Studies on attractants have resulted in the discovery of a number of highly attractive materials, some of them many times more attractive to the fly than any heretofore developed. In this work the cooperation of the Florida State Experiment Station is acknowledged. With the use of new attractants and those formerly known, an exhaustive trap survey of all infested counties is being conducted. In this way the rise and fall of the fly population has been closely followed, and this has permitted valuable improvements in the eradication operations, both in regard to spraying and in regard to clean-up of hosts.

The study of the wild flora constitutes one of the basic features of the eradication campaign, since dissemination of the fly into the uncultivated wilds would make eradication impossible. It consists in an examination of all fruiting plants considered as possible hosts for the fly, first for possible infestation, second for fruiting period, and third for relative abundance. To date, over 300 square miles of wild territory skirting infested properties has been thus intensively studied. One hundred and sixty-one species of wild fruiting plants considered as possible hosts have been encountered, studied, and tabulated in detail in these 300 square miles. No infestation has been observed in any of them.

With this study in progress, a second investigation is under way. The entire State has been divided into floral areas, and 10 rather distinct types of plant communities have been found to constitute these floral areas. Quantitative surveys of these communities are being made throughout the infested territory and in other territories liable to infestation. This is done by marking off different blocks in these associations, each containing 10,000 square feet, and recording each individual plant in such blocks. Blocks are followed through the season to record changes therein. To date, 63 of these blocks, covering all known plant associations, have been studied. The purpose of this study is to enable the research organization to provide clean-up forces with exact data on the percentage of any plant known to be, or later determined as, a host in any type of land that it may be necessary to clean.

The study of the cultivated fruiting plants has included all cultivated plants bearing fruits which show possibilities of serving as hosts. The study to date has covered 122 species of such plants. One phase of this work has been the development of a calendar for all known hosts, showing the periods throughout the year in which these host plants are in fruit in the three districts of the State liable to infestation. This has permitted a determination of the relative hazards presented by the cultivation of these different plants in any territory likely to harbor the fly.

A second study under this project has covered the varieties of citrus fruits under commercial production, as to their distribution, the quantities produced, and the dates of maturity. Information along these lines should indicate the fly hazard in relation to maturity as well as in relation to the shipping problem. An additional assignment to this project has been the town and city surveys. Practically every city and town in 14 counties of the State has been scouted and quantitative surveys made in several of the older ones to determine the quantity of host trees existing.

Fruits of all species taken in the surveys both of wild and of cultivated

fruiting plants are exposed to the flies for oviposition purposes. Special attention is given to those plants which are of economic importance or which exist in abundance. Oviposition has been attempted in 39 of these fruits, and larvæ have been developed to maturity in 29. In other cases larvæ have been able to develop when inserted artificially into the fruits, but the adults have been unable to infest the fruits in a normal manner. Citrus varieties at different stages of maturity are also exposed to the flies in cages in order to determine at what stage of maturity these fruits will be acceptable to the fly. Fruits of the same age and variety are measured in each case for the maturity ratio, so that it can be determined at what stage of marketability fruits may be attacked.

Following studies in the Mexican laboratory, an artificial medium has been prepared in which the larvæ are able to develop and pupate. Since this medium is of known chemical composition, it permits the addition of materials to determine if pupation may be prevented, the object being to develop a material suitable for application to the various types of soil. The studies so made have been carried to the field, and soil samples have been collected from various groves, (1) from those parts of the groves where pupæ have been found in abundance, and (2) from those parts where they have been scarce. It has been found that the soil containing many pupæ has given pH readings of 6 to 8, whereas soils from those parts of the groves where pupæ were rare have given readings of about 3. Following the tree-tolerance theory on which the new insecticides have been developed, studies are under way on tree fertilization in the hope that some material may be found which, applied to the soil, will inhibit pupation of the fruit-fly maggots.

In experiments conducted at the Hawaiian laboratory, the possibility that susceptible fruits which have been exposed to certain low temperatures can be guaranteed as safe for shipment to other States has been investigated. These studies have been conducted with small equipment at the laboratory and checked in a commercial precooler in a packing plant. The infested fruit used in experimentation was, in the most extensive experiment, wrapped and given commercial pack. It was found that in fruit subjected to a temperature of 28° F. for five hours and held for four and one-half days at 30° all larvæ, even those most mature, were killed. In determining the influence of such treatment on the fruit, this bureau had the cooperation of the Bureau of Plant Industry for tests made in Washington on fruit shipped for the purpose. After the fruit had been held there at these temperatures for extended periods it showed no unusual injury.

Owing to the excessive time necessary under such a method of safeguard, and following promising results obtained from holding fruit at high temperatures in the Mexican laboratory, efforts were made looking toward the use of high temperatures and humidities for safeguarding fruit. After a series of experiments at different temperatures it was discovered that all larvæ were dead in fruit held at an inside fruit temperature of 110° F. for eight hours. In all the types of oranges and grapefruit available on the trees at the time no apparent injury resulted from such treatment as far as flavor or character of the fruit was concerned. No early fruit was available for test, and the influence of such treatment on early fruit remains to be investigated. The experiments, at first conducted on a laboratory scale, have been transferred to commercial coloring rooms, where a complete kill of larvæ has been obtained in infested oranges placed in different locations in the car lot of fruit. Difficulty, however, was experienced in adjusting the temperature in such rooms, and this difficulty remains to be overcome.

It is well known that heavy loss from stem-end rots has been experienced when coloring-room temperatures have been raised to slightly over 90° F. Higher temperatures, however, have not been attempted in coloring rooms. Counts for rots in the experiments undertaken showed a very marked reduction in the number of rots in the heated fruit as compared with the number in the unheated. These figures appear so promising that the cooperation of the Bureau of Plant Industry has been obtained in an extensive series of experiments looking toward the elimination of such rots by treatment at high temperatures. Preliminary experiments with cultures and inoculations have given very favorable results. Heat tests with avocados have also been conducted without any apparent injury to the fruit. In all tests the humidity is held very high.

At the Hawaiian laboratory tests have been conducted with different attractants advocated in other countries. Such tests can be carried on to advantage in the Hawaiian Islands, since flies are abundant there. It was discovered that the peach lure considered very attractive in Australia captured very few flies. The possibility of larvæ surviving in citrus juice was also investigated at that laboratory. This issue was raised in connection with some of the disposal practices in Florida. Two experiments were conducted, in one of which the larvæ were permitted to obtain air at the surface of the juice, while in the other this was prevented. Out of 1,447 larvæ in the first experiment, none survived over five days. Out of 7,800 larvæ in the second experiment, none survived 72 hours. Studies on the susceptibility of Guatemalan avocados have been continued. These have included studies of fruits in cages, of fruits inclosed on trees, and of fruits collected in the field. Under forced cage conditions even the thickest-skinned varieties were infested. In the field, however, out of 1,269 fruits of the Guatemalan varieties held for observation only four proved to be naturally infested. Studies of the parasites of the fruit fly have been continued, and a shipment of 3,000 pupæ made to Australia in order, if possible, to establish parasites in that country.

THE MEXICAN FRUIT WORM

Studies have been continued in the insectary in Cuernavaca, Mexico, not only on the Mexican fruit worm but on the larvæ and adults of other species of fruit flies occurring in that region.

Owing to the usual method of fruit disposal, experiments were conducted in burying to different depths fruit containing larvæ. Although no adults of *Anastrepha striata* Schiner were able to emerge from a depth greater than 9 inches, adults of the Mexican fruit worm (*A. ludens* Loew) penetrated through 18 inches of soil in several experiments. It was found, however, that many more could reach the surface when the fruits were buried in a shaded location than if they were buried in one exposed to the sun. This probably accounts for the protection afforded by burial to the 18-inch depth in the Rio Grande Valley.

With regard to the common fruit flies in Cuernavaca, namely, *A. ludens*, *A. striata*, and *A. fratercula* Wied., a series of experiments proved that the adults are attracted to trees other than those of their natural hosts even in the presence of their host trees. The mango is the favorite fruit of *ludens*, is very seldom attacked by *striata*, and is never attacked by *fratercula*, but in the adult-fly population of 40 mango trees *striata* occurred almost as commonly as *ludens*.

It is obvious from experiments conducted that current conceptions in regard to the longevity of *A. ludens* must be discarded. A length of life of seven months is easily indicated. The premating period of a series of flies emerging in January averaged 25 days, and even males were alive after five months. The egg-laying capacity of the species is also much greater than was supposed, one female depositing 298 eggs during a period of 47 days.

The work in the laboratories in Mexico City has yielded results which it has been possible to apply in the fight against the Mediterranean fruit fly in Florida. A study of the temperature tolerance of the larvæ in mango fruits showed that these could be killed in the fruits at about 110° F.

Experiments on the relation of pupation to soil acidity showed that this activity is largely controlled by the condition of the medium in which the larvæ find themselves, and that pupation may take place within the fruit if the conditions of acidity are suitable. The influence of moisture is also marked.

One very interesting study which has an important bearing on the Mediterranean fruit-fly situation was conducted in the laboratory. It was believed that the adult flies were feeding on wild yeastlike organisms which occur on the outside of the fruits and elsewhere. An artificial medium was therefore prepared, the only source of food used being cultures of the yeast carried on the legs of the flies. Adult flies were confined to this medium, and they were still alive after two and a half months, having had no other source of food but this yeast. It is evident, therefore, that fruit flies can survive for long periods feeding only on wild yeasts, and this fact must be taken into consideration in any eradication campaign. It has been found in Florida that yeasts may form an important article of diet of the Mediterranean fruit fly, since flies that were dying rapidly on sugar and water survived long periods if given yeasts.

Besides the studies carried on in the insectary at Cuernavaca and those in the laboratory at Mexico City, an ex-

tensive ecological survey of the heavily infested districts of Mexico has been conducted. Centering in Cuernavaca, the survey has covered the western slope from Tepic to Oaxaca, and on the eastern slope the area about Jalapa, Cordoba, and Vera Cruz. This survey has included a study of the climatic conditions, the character of the soils, the vegetation and fruit production, and the fruit worm and insects associated with it.

INSECTS INJURIOUS TO ORNAMENTALS

The work on insect pests of ornamentals has been conducted, as heretofore, mainly in the laboratory in New Orleans, in California, and in the Northwest. In the latter section the interest of the growers has been evidenced during the year by their erection of a first-class laboratory building at Sumner, Wash., in which the investigations may be conducted under modern working conditions. Besides containing offices, laboratories, temperature room, and photographic facilities, the laboratory plant has a large greenhouse permitting three temperatures, an insectary, and a shop. Ample ground is provided for experimental plots.

Investigations at this new laboratory are at present largely confined to work on bulb pests. One of the interesting developments of the year is the determination of a new variety of mite which lives within the bulbs, especially near the neck, the activity of which stunts and distorts the leaves. Experiments in control have indicated that the mite yields to the hot-water treatment devised for bulb flies. Fumigation studies on the control of bulb flies have been continued, particularly experiments in handling case lots of bulbs. Extensive series have been run but inconsistent results have been obtained, and an effort is now being made to determine the causes of this inconsistency. Studies in regard to field control are also under way. These have comprised some 65 field plots and a large variety of materials, but conclusions have not yet been drawn from the records.

The major work on bulbs for several years has dealt with hot-water treatment for the bulb flies. This has had two phases, one touching the flowering quality of the bulbs and the other the weight of the bulbs. It is on the second phase that the work of the year has been concentrated.

During the year the occurrence of the red spider on asparagus ferns in Florida caused heavy losses to the fern growers, and an investigation was at once undertaken covering its biology and possible control. It was determined that clean culture in the fernery and in a belt 8 or 10 feet wide around it, and two spray applications seven days apart, in which 1 part of 5 per cent Derris extract in 400 parts of water was used, would give relief.

In New Orleans, work has been continued on the development of lubricating-oil emulsions in camphor-scale control, and on certain studies of fumigation with hydrocyanic-acid gas. The fumigation work immediately in hand was planned in the hope of determining if the toxic action of hydrocyanic-acid gas bears a definite relation to its source and if different forms of cyanide are of equal value in yielding the gas. As to the first question, the cyanides of calcium appear to give a higher mortality than the other forms. And the second question, judging by the results so far obtained, appears to be answered in the negative.

PARASITES AND PREDATORS

Besides the work on parasites of the Mediterranean fruit fly, previously mentioned, two projects of the division fall under this general heading. The first is a cooperative project with the Department of Agriculture, Commerce, and Labor of Cuba, devoted to the importation of parasites of the citrus black fly into Cuba and those of the citrus white fly into the United States. This project has just been undertaken, with field headquarters in Singapore. Up to the present no parasites have been shipped, but a number are known from several regions of the Orient, and it is hoped that colonies of considerable strength will soon be built up.

The second project involves a thorough study of the influence of environment on the Vedalia beetle in order to determine the basic principles underlying the predatory relation. During the year the feeding rate was studied and was found to be a function of temperature, age, seasonal change, and sex. Observations at short intervals showed that the periodic nature of the feeding of the beetle was modified by light conditions.

INVESTIGATIONS IN CALIFORNIA

Through the interest of the citrus industry of California, a fund has been established for the construction of a modern, thoroughly equipped laboratory, the building of which is now un-

der way. This will be one of the most up-to-date entomological laboratories in North America and will be the center of all of the division's work in the Southwest.

At present investigations on bulb flies are under way in California following the same general program as that in the Northwest. Citrus-thrips investigations have developed, in dusting with sulphur, an excellent insecticide. Continued investigation of the heat treatment for the date scale has refined the method to a point where it is hoped that in another year or two it can cover several types of conditions. A new insect, however, a mite, is becoming rather widely distributed in date gardens. This mite has been discovered not only on palms but on various species of grass and upon corn. A thorough investigation of the pest will be undertaken as soon as facilities permit.

TRUCK-CROP INSECT INVESTIGATIONS

Investigations on vegetable and truck-crop insects have been continued during the year under the general direction of J. E. Graf and W. H. White.

MEXICAN BEAN BEETLE

The addition to the territory occupied by the Mexican bean beetle occurring in the season of 1928 is probably of more importance than that of any previous year since the discovery of this insect in the eastern part of the United States. The beetle, upon reaching the important bean-growing areas in Maryland, New Jersey, and Delaware, reproduced rapidly, and there seems to be but little doubt that it will become a pest of major importance there. The beetle is now known to occur along the Atlantic seaboard from northern North Carolina to northern New Jersey. In North Carolina the beetle reached the coastal plain in at least six counties. Six counties in southern New York have become invaded, and two in Michigan. The spread to the West has been slow, no new territory having been reported as infested with the exception of four counties in northern Indiana. On the southern edge of the infested area in central Alabama and Georgia and in northern Mississippi conditions are apparently not normally favorable for the survival of the beetle, as no appreciable spread has been recorded in these sections for five years.

The increased injury by the beetle resulted in greater interest on the part of growers, particularly the canners, with the result that control measures were used much more widely than ever before. As in past seasons the most effective control was obtained by spraying with magnesium arsenate Calcium arsenate, applied as a dust, was also effective against the insect, but in many instances, particularly in certain sections of the Atlantic coastal plain, plant burning followed treatments with this chemical, and some brands caused marked crop injury even when diluted with seven parts of lime. This development resulted in an enlargement of the program of work on insecticides. Pyrethrum extracts gave very good control of the beetles when applied at frequent and regular intervals. Tests with 18 fluorine compounds showed that barium fluosilicate was quite toxic to the insect but that it also caused severe plant injury. Several other fluorine compounds, including manganese fluoride, lithium fluoride, strontium fluoride, sodium fluosilicate, and copper fluosilicate, were toxic to the insect but this toxicity was subject to considerable variation, and rather heavy plant injury resulted in some instances. The application of remedies by commercial growers yielded encouraging results. Although poor control of the insect was apparent in a few cases and insecticidal injury appeared in others, a majority of the growers were well satisfied with the general results.

Biological and control studies were continued in New Mexico. Only one generation of the bean beetle occurs there annually, the adults spending an average of about 260 days in hibernation. It has been definitely ascertained that the most successful hibernation takes place in the yellow pine and oak zone. Above this zone the insect perishes. Control studies indicated that one treatment, properly timed, would more than pay for itself in the increase in yield of bean vines alone.

SWEETPOTATO WEEVIL

Experiments in the eradication of the sweetpotato weevil were continued in Alabama and Mississippi in cooperation with the States concerned. The work in both States has been systematized so that one general plan is followed. Scouting is conducted periodically during the year. All potato fields on infested farms are thoroughly cleaned at harvest, and all storage banks and houses are cleaned in the spring. Planting stock for the suc-

ceeding crop must be weevil free. The outstanding development of the year was the fact that no weevils were found in Baldwin County, Ala. The cleanup of this county was partially offset, however, by the finding of a new infested area in Pearl River County, Miss., comprising 16 properties. At the end of the year the infested properties for the whole area under observation were distributed as follows: In Mississippi, 19 in Pearl River County and 16 in Hancock County; in Alabama, 22 in Mobile County and none in Baldwin County. Information collected on the biology of the sweetpotato weevil indicates that this insect flies more readily than was formerly supposed. Definite records of flight, both during the day and at night to lights, have been made.

WIREWORMS

At Walla Walla, Wash., extensive rearing experiments are being made in the laboratory with eight species of wireworms commonly found in that section. The two primarily concerned in crop injury are *Limonius canus* Lec. and *Pheletes occidentalis* Cand. Approximately 87,000 eggs were placed under incubation, and from these 14,000 larvæ had been obtained up to June 30. Field studies include unit screenings of the soil to obtain data on the seasonal changes in wireworm population and at the same time readings in each field under observation as to soil moisture, soil temperature, and hydrogen-ion concentration. This phase of the work has for its object the determination of the factors favorable and unfavorable to wireworm development and damage. Control work is carried on under both cage and field conditions and includes tests with poisoned baits, contact insecticides, and soil fumigants. Where the return from the crop allows for considerable expenditure per acre good results in controlling wireworms have been obtained from the use of carbon disulphide applied directly to the soil. When it is used at the rate of 1 fluid ounce in holes 4 inches deep and 18 inches apart each way, the diffusion of gas in the soil will give a kill of the wireworms approaching 100 per cent. For best results the soil should be uniform, of loose texture, with at least 10 per cent moisture content and with a temperature above 50° F. Similar studies are being carried on at the substation at Toppenish, Wash., and field-plot experiments are being conducted to determine the influence of crops and cropping on the seasonal abundance of the wireworms in the soil.

In California continued tests with bait materials for the attraction of wireworms showed that for the first two-weeks' period wheat and beans are superior to corn or milo. Tests with aromatic chemicals in baits gave no striking results except that nitrobenzene appeared to be quite consistently repellent. Experiments with varying soil temperatures where the wireworms were free to choose the temperature most suitable to them showed the greatest concentration of worms where the soil was between 50° and 60° F. Eggs hatched and the wireworms developed in soil having a wide range of hydrogen-ion concentration.

Biological and control work on the group of sod-land wireworms, which includes the wireworms attacking corn and tobacco, is being continued at Chadbourn, N. C. Tests to determine the attractiveness of baits corroborated the findings of last year and showed that of themselves the baits or plants exhibit little or no attraction to the wireworm *Monocrepidius vespertinus* Fab., but the wireworms follow the rows where the soil has been disturbed for planting or placing of the baits. Field studies have shown that late-planted tobacco suffers only minor injuries from wireworms, but the farmers are prejudiced against late planting. Rearing work under way indicates that the species concerned in the major portion of the injury have a life cycle of at least 2 years. Studies on cropping methods have shown that the growing of either corn or cotton on the land during the two years preceding the planting of tobacco increases the chances of wireworm injury to the tobacco. Test plots to determine the effect of cropping on the population of the corn wireworm (*Horistonotus uhleri* Horn) have been started.

Laboratory tests are under way to discover a poison toxic to wireworms and one which can be adapted to poisoned baits. Various chemicals are being tested, both by injection and by voluntary feeding. Arsenites, especially sodium arsenite, proved more toxic than any other material under conditions of forced feeding. It was difficult to induce enough voluntary feeding to prove the usefulness of any of the materials tested.

POTATO INSECTS

Biological studies were continued at Chadbourn, N. C., on the seasonal life history and behavior of the seed-corn maggot as a potato pest in the field. The location and stage of this insect during the months of July and August are still undetermined. Control studies in the field were conducted on both potatoes (seed pieces) and spinach seedlings. This work included, in the case of spinach, a study of the effect of fertilization and the previous crop on maggot injury. Spinach fields fertilized with organic fertilizers or containing large quantities of humus suffered the heaviest injury from maggots. Mineral fertilizers are not attractive to the flies, and the smallest loss occurred on soil low in organic material and fertilized with mineral materials. Other factors being equal, the larval population of a soil during the breeding season seems to be directly proportional to the quantity of partially decayed organic matter that it contains. The time of application of the fertilizer was found to be of considerable influence on subsequent maggot injury. In cooperation with the Bureau of Plant Industry tests were continued on the protective effect of seed suberization prior to planting. These tests again showed that properly suberized seed was not as susceptible to the attack of the maggot and to decay as freshly cut seed pieces.

STRIPED CUCUMBER BEETLE

Experiments conducted with the striped cucumber beetle were concerned largely with the effect of food upon oviposition and comparative experiments on control with several dusts under field and cage conditions where temperature was considered in relation to the effectiveness of the material. Calcium fluosilicate gave promising kills only under conditions of high temperatures. Sodium fluosilicate killed high percentages of beetles in cages and appeared to have a marked repellent effect. This material caused plant injury in about half the tests. A calcium arsenate-gypsum mixture gave high kills of beetles in cages, but usually required from 48 to 72 hours to effect a kill. Under field conditions it appeared to be decidedly repellent. Nicotine dusts were more effective under high temperature with clear weather and low winds than when the opposite conditions prevailed. The beetles died quickly under such conditions in both cage and field tests. These tests showed that under satisfactory climatic conditions a dust containing from 2 to 4 per cent of nicotine is a satisfactory remedy for the striped cucumber beetle.

BERRY INSECTS

Further experiments with sticky screens as an index to the strawberry weevil's emergence from and location of hibernation quarters showed that the principal weevil infestation in the fields came from the first 100 feet of adjoining woodland. By careful burning of this narrow strip the spring infestation has in cases been reduced to the point where direct control of the insect with poisoned dust was unnecessary. This burning of woodlands is not advocated unless conditions are such that the fire can be confined to the area harboring the overwintering weevils. The most important cultivated food plants of the weevil in North Carolina are the strawberry, dewberry, and blackberry. The most important wild hosts are the huckleberry, chokeberry, wild blackberry, and dewberry. Survival of larvæ in cut buds is largely dependent on the stage of development of the bud and on moisture conditions. The mortality of larvæ is greatly increased in the presence of excessive or insufficient moisture.

The cyclamen mite, until recently recognized as a pest only in greenhouses, was destructive to experimental plantings of strawberries at Geneva, N. Y., the plants being greatly stunted and weakened. Several materials were tested as remedies under field conditions. Sulphur gave the best results, but the control was so slight that it can not be recommended as a remedy on the basis of these experiments. Laboratory tests were made on submerging nursery plants in hot water at 115° F. for eight minutes and in a 2 per cent white-oil emulsion at 110° for five minutes. The treatments did not seem to injure the plants, but their effect upon the mites is as yet undetermined.

Further experiments on the control of the common red spider as a pest of strawberries were conducted in Louisiana. Numerous dusts and sprays were tested, but only the former gave promising results. The sulphur dusts, both undiluted and in combination with other materials, gave the best results, and the quickness of action

and effectiveness appeared to be in proportion to the percentage of sulphur in the mixture. The undiluted sulphurs gave very good control as heretofore, both in commercial and in experimental plantings, even under unfavorable weather conditions.

SUGAR-BEET LEAF HOPPER

The life history of the sugar-beet leaf hopper has been followed in detail in southern Utah, so that data will be available for comparison with its development in previous years. Entire populations of different species of insects on the principal host plants of the sugar-beet leaf hopper have been studied on a quantitative basis with a view to ascertaining the species involved, the relative numbers of each, and the factors responsible for such relationships. Investigations of the egg parasites of the leaf hopper have revealed the hibernation places of the parasites, and data are available on their comparative numbers from various locations in southern Idaho. Studies on the insect associations of the mustards which fill one of the most important gaps in the succession of the leaf-hopper host plants in southern Idaho have been brought to the point where investigation of the competition of various insects for this plant as a source of food may be attempted.

Observations of the effect of climatic conditions on the development of the leaf hopper have been continued, with a view to obtaining data which will make possible the estimation of the possible abundance of the pest and its effect on beet culture. The growers of the Twin Falls district were informed that prospects of leaf-hopper injury for 1929 were slight, and this statement was followed by the planting of the largest acreage in the history of the district. On June 30 leaf-hopper populations were unusually low, and the chances of crop loss from this source appeared slight. In connection with the study of climatic factors affecting leaf-hopper abundance, the effects of climatic variations have been observed on other insects, notably cutworms and flea beetles, both of which rose to prominence in 1929, the outbreaks being associated with a distinctive type of winter and spring weather.

Search in Mexico for egg parasites of the leaf hopper did not reveal any species not known to occur in the United States. This investigation also established the fact that permanent breeding grounds of the leaf hopper extend over 500 miles south of the international boundary. Surveys for the sugar-beet leaf hopper in Montana confirmed the previous belief that Montana, by virtue of the climatic conditions prevailing there, will be free from economic losses due to the sugar-beet leaf hopper. Similar surveys, conducted in cooperation with the States concerned, are under way in Iowa, Texas, New Mexico, Utah, and Oregon. The work in Oregon has indicated that though certain areas are obviously unsuited for beet culture, owing to their close proximity to the leaf hopper's breeding grounds, there are, nevertheless, certain small irrigated valleys which are worthy of further study to determine their probable status as leaf-hopper-free areas.

TOBACCO INSECTS

Investigation of the life history of the tobacco stalk borer in Tempe, Ariz., has shown that eggs are laid each month of the year and are deposited singly in punctures on almost any part of the plant. A period of from 47 to 72 days is required for development from egg to adult. The adult weevils feed on any part of the plant, the tender leaves being preferred. The problem of control is complicated by the fact that the adult is easily repelled by poisoned foliage and the larvæ can not be reached by insecticides. Several wild plants are hosts and serve as a source of food supply for the insect in the absence of tobacco.

Since tobacco is treated with arsenicals for the control of insect pests, an investigation of the arsenical residues remaining on tobacco leaves at maturity was necessary. In cooperation with the Bureau of Chemistry and Soils analyses are being made of tobacco leaves taken from treated plots in the field at different periods, also after harvest and curing, to determine the quantity of arsenic remaining after handling and processing. At the same time other insecticides are being tested in an endeavor to find a substitute which can be used on tobacco without exposing the product to possible rejection on account of high arsenical residues.

MUSHROOM INSECTS

In cooperation with the Pennsylvania State College of Agriculture and the Bureau of Plant Industry of the department a study of mushroom pests and their control was inaugurated January 1. Because of the short time

this project has been active the results obtained are of a preliminary nature. The principal line of investigation followed has been the control of mushroom flies. The comparative value of fumigation with pyrethrum dust and fumigation with smoke from burning pyrethrum has received considerable attention. The objective of this phase of the work is reduction in cost of treatment with pyrethrum and increase of its efficiency through a more even distribution of the toxic agent throughout the house.

Another phase of the control work which shows promise of practical employment is the use of natural light as an attracting agent to the flies. Preliminary tests were made with glass panes inserted in the doors of the house, the inside of the doors being covered with commercial fly papers to catch the flies as they flew to the light. In one test where a 6 by 18 inch glass pane was used in each of the five doors of a heavily infested house approximately 370,000 flies were caught during a period of six hours. While it is not believed that this method alone will effect control of the mushroom flies, the indications are that it will be a valuable adjunct to fumigation.

MISCELLANEOUS

Life-history studies on the pepper weevil developed the fact that six generations may occur in southern California. The insect breeds throughout the year, both in peppers and in nightshade. The biology of the insect is similar on both plants, but mortality is higher in nightshade. Infestations as a rule were lighter the past season than during the preceding season, but because of the losses suffered by growers last year most of them resorted to dusting. Calcium arsenate continued to give the best results in controlling this insect, but its use increased indirectly aphid infestations in some sections. Nicotine dust was used for aphid control, but wind and temperature were unfavorable most of the time, and the application of improperly made dusts added to the generally mediocre results obtained in controlling the aphid. In general, spraying yielded more consistent results. The use of calcium arsenate necessitates the removal of arsenical residues before the peppers are marketed or dried. Cultural control has demonstrated its usefulness against the weevil, and the systematic cleaning up of the overwintering food sources of the weevil—that is, nightshade and old pepper fields—may make necessary only the occasional employment of direct measures against this pest.

Studies on the relation of climate to the growth of the pea vines and the development of the pea aphid are being continued in Wisconsin. The weather so conditions the plant growth on one hand and modifies aphid reproduction on the other that in the average year the plants withstand the infestation produced under such conditions without showing appreciable commercial damage except in rare instances. It appears that natural enemies are not a decisive factor in aphid control until the plants have approached near enough to maturity so that aphid reproduction on the peas has almost ceased and the infestation fallen considerably below its peak. Dusting and mechanical-control tests were continued, and the effect of these treatments on the insect, on the total yield of peas, and on the grade rate and quality of the canned product was determined. The results were comparable to those of the last three years. They brought out more clearly, however, the fact that under favorable conditions of plant growth it is not only unnecessary to attempt mechanical control of the pea aphid, but that the application of such measures may be detrimental to the crop. Studies on the relation of the insect to its environment are being continued in Wisconsin and New York.

A large series of laboratory tests were conducted on the control of the celery leaf tier to determine what insecticides might be useful under field conditions. The work with arsenicals showed that a quantity required for efficient killing of the leaf tier would leave an objectionable residue on the plants. Various fluosilicates were tested, and although the toxicity to the insect by several of these compounds was satisfactory they caused such consistent foliage injury that their use was abandoned. Pyrethrum, which had been used by growers during the last season, was found to be the only material which was toxic to the leaf tier and at the same time not injurious to the celery foliage and which also left no objectionable residue on the plants. Extensive experiments were undertaken with the object of lessening the costs of pyrethrum treatments. The result of the work showed that 50 per cent dilutions of pyrethrum with lime or sulphur were satisfactory from the standpoint of commercial control of the insect. Improvements in meth-

ods of applying the dust so as to force it into the center of the plants increased the insect kill to a marked degree. Work on rearing the egg parasites of the leaf tier for distribution in the field has been continued, but thus far difficulty has been experienced in obtaining maximum oviposition from the laboratory-reared parasites, and this has resulted in only slightly increased parasitism in the field even when relatively large numbers of parasites were liberated. An ecological study of the occurrence of the leaf tier at different stages of development of the celery crop has included a study of the predacious insects and birds which may influence the abundance of the pest.

Investigations on the development and control of the European earwig were initiated in Washington State at the beginning of the year. This insect, for some years noted as a pest in towns and cities, is showing a tendency to become an agricultural pest and is spreading into rural communities. It has caused considerable damage in market gardens by its attack upon cabbage and carrot seedlings. It hides in and feeds upon the heart of celery; beans, potatoes, and peas are eaten readily. The earwig finds its way to market in the heads of cabbage and lettuce and beneath the husks of sugar corn, making such vegetables less desirable and consequently reducing their market value. The pest occurs more abundantly in the humid districts of the infested section than elsewhere, although it has been able to maintain itself in several communities where irrigation is practiced. Experiments with poisoned baits are under way, but extensive trials under different conditions will be required to demonstrate those of greatest value.

In the Gulf region the vegetable weevil has continued to spread, and 27 additional counties are known to be infested. Its known distribution in the Gulf region is as follows: Alabama, 19 counties; Florida, 3 counties; Mississippi, 50 counties; and Louisiana, 13 parishes. Biological investigations have shown that the weevil flies more readily than had been supposed, and it is apparently by this method that local spread occurs. The list of host plants has been increased by the discovery that it is able to live on several additional wild plants. Estivating adults have been found in numbers under the loose bark of pecan trees. The insect feeds readily on several baits prepared from some of its preferred foods; but on first appearing from estivation, the beetle shows for a few weeks a slight preference for growing plants. In California the extended cold weather during the season of 1928–29 delayed the development of the vegetable weevil, with the result that there was less damage than usual to susceptible crops.

INSECTICIDES

Physiological studies are under way to determine the effects of various poisons on certain insects. The influence of injections of several poisons on the gaseous exchange of the Colorado potato beetle has been studied. Another activity dealt with the study of enzymes found in the digestive tract of insects, their effect on the solubility of arsenicals, and the possible inhibiting effect of the arsenic on enzyme activity. Work is also under way on the determination of the distribution of arsenic in insect tissues. A method is in process of development which will make such a study possible and may be of considerable value in indicating more exactly the manner in which arsenic kills.

COTTON INSECT INVESTIGATIONS

B. R. Coad has continued in charge of investigations of insects affecting the cotton plant.

The boll weevil continues to dominate the cotton-insect investigations of this bureau, although during the year there has been considerable enlargement in the studies devoted to other insect pests.

BOLL WEEVIL

The hibernation studies on the boll weevil as listed in previous reports have been continued with some slight expansion. The 14 cooperating agencies have somewhat increased the scope of their work, and in the investigations of this bureau new points have been added to represent sections which were not included in earlier records. Still further expansion of this sort is needed and contemplated. The reports issued on these hibernation observations have been considerably curtailed and now include only those data which past records have shown to be of most significance in the prediction of weevil activity.

The dusting-machine investigations have largely centered around improved machinery and technic. The develop-

ment of dusters with high air velocity has permitted the construction and introduction of entirely new types which are making it possible to dust much more cheaply and under more adverse conditions than in the past. New types based on these principles are now appearing on the market at prices considerably lower than those of older models and with a greatly increased efficiency. These same principles are being applied experimentally to duster attachments for cultivators, and equipment is now being tested and designed for the various types of riding and power cultivators. In addition, a survey is being conducted to determine the needs of various districts for machines of these types. In conjunction with these machine developments, the swath tests of all types are being continued, a simplified, more rapid form of test being utilized which has evolved from the elaborate swath-width observations of the past several years. The efficient swath rating for each type of machine has been determined for the older standard types and is being determined for the new types as they appear. Special attention has been devoted to the so-called cloud-drift method which has received considerable publicity during the last two years. A number of machines have appeared on the market which blow out large quantities of dust and allow this to drift across the field so that swaths from 300 to 500 feet in width can be treated. Careful tests of such dust clouds have shown a very heavy wastage due to overdosage close to the machine and an irregular, inefficient dosage through the remainder of the swath.

The studies of weevil flight have been combined with the investigations of chemotropism which had progressed in the laboratory far enough to show certain materials as attractive to the weevil in laboratory tests. These materials are now being tested in the field-flight studies in the effort to determine whether or not they can be made attractive under field conditions. Results of the past studies on migratory flight indicate that in the territory around Tallulah, La., there is much less relation between the distribution of cotton planting one year and the resultant infestation with weevils the following year than had been previously supposed. This is very important in connection with any attempts at weevil control in the fall, such as fall destruction of stalks and fall poisoning.

The plat tests at Tallulah have been continued on a reduced basis and have consisted largely of tests of new or improved insecticides and the standard series of weevil-damage tests. The series of these weevil-damage tests completed in the fall of 1928 showed some of the largest gains from poisoning which have been secured in the 13 years these tests have been running, these gains averaging 390 pounds of seed cotton per acre with a maximum gain of 1,542 pounds of seed cotton per acre.

The cooperative investigations in the State of South Carolina have been continued with some enlargement. The plat tests on early poisoning are being continued and a standard series added to check the amount of weevil damage under various conditions. In addition, the weekly report on weevil activity throughout the State is provided for the use of the State authorities in issuing timely advice on weevil control.

The similar cooperation with the State of Oklahoma is being continued and enlarged. The control tests are new conducted at three stations—Ada, Hugo, and Muskogee. Results of these control tests for the growing season of 1928 indicated that under the conditions of that season the methods developed elsewhere throughout the South gave most profitable results. However, it is necessary to continue these tests for a few years so that they will show the effects of seasonal fluctuations. The results for the season of 1928 have been published by the Oklahoma station.

COTTON FLEA HOPPERS

Investigations of damage by cotton flea hoppers have continued to center around the more technical, fundamental studies, although close observations have been maintained in many sections of the South for the purpose of following field conditions and damage. Six different species of insects have now been incriminated, and a report has been prepared describing the type of injury produced by each. In addition, considerable progress is being made on a technical study of the nature of this injury and its possible causes. Investigation of direct control has centered largely around a study of the nature of the toxic action of sulphur on the insects and the factors influencing it. So far these continue to point to the importance of high temperatures and bright sunshine immediately following an application.

ARIZONA WEEVIL

Studies of the adaptation of the Arizona weevil to cultivated cotton have been continued at the isolated ranch. Weevils have now been carried through four years since they were removed from their wild host plants and have been started on their fifth year with the complete record of their life history and biological activity, especial attention being given to any modifications or changes in habits which seem to be developing. A manuscript has been submitted summarizing all of these studies to date. The survey on distribution in nature has been completed as far as the United States territory is concerned, and a report is in course of preparation. In addition, the regular studies on activity and distribution in cultivated cotton have been maintained. These show a continued increase in infestation in the southern Santa Cruz Valley and a gradual spread and increase to the northward in this same valley. No new infested districts have been reported within the year.

PINK BOLLWORM

The organization of pink-bollworm research as described in a previous report has been still further expanded. A research laboratory has been installed at Presidio, Tex., and various sublaboratories, including one in the Laguna district of Mexico, are in operation. At all of these an effort is being made to build up a complete picture of the life history and habits of this insect with special reference to those features which are of primary importance in control or eradication. During the year an extensive study was made on the flight of this insect, including an airplane expedition to the Laguna district of Mexico. It was found that while moths have no tendency toward flight or activity above the plants through most of the season, they become very active about September 1, and individuals were collected at all altitudes up to 3,000 feet. These records, combined with the infestation and trap-planting records, give strong indications of the importance of wind carriage as a means of movement of this pest.

Special attention is being devoted to the question of host plants and the possibility of this species perpetuating itself on those host plants other than cotton which have been recorded in the past. So far specimens have been carried through the winter on both okra and a wild Hibiscus found in Mexico, but summer reinfestation has not been established.

A new project of cultural control has been undertaken in cooperation with the Division of Agricultural Engineering of the Bureau of Public Roads. This includes a study of plowing equipment and methods combined with irrigation processes to determine those methods which are most effective in killing off overwintering individuals.

Recent observations have directed particular attention to the gin as a concentration point for pink bollworms and to the importance of destroying the individuals present in the gin trash. Consequently another cooperative project with the Division of Agricultural Engineering has been inaugurated, and all possible variations of three basic methods of gin-trash disposal are being studied. These methods include incineration, sterilization, and milling. The studies cover relative effectiveness of the different methods as well as costs and specifications for necessary equipment. These will be used as a basis for definite recommendations and regulations for the pink-bollworm territory. In addition there has been a growing appreciation of the importance of the gin as a concentration point for boll weevils and other cotton insects and evident willingness on the part of many ginners to install equipment to render the gin trash free of such pests. Consequently it is hoped that the equipment which is being developed primarily for the pink bollworm can also be utilized throughout all sections of the Cotton Belt where pests are important.

COTTON BOLLWORM

The cotton-bollworm investigations have now been reorganized and placed on the same basis as those on the pink bollworm, all studies in the State of Texas being carried out in full cooperation with the experiment station of that State. These include a study of the influence of modern farming practices on bollworm infestation and the possibility of direct control measures, as well as studies on the relation of bollworm damage to cotton-louse infestation and weevil-control measures.

INSECT MIGRATION

At the end of the season of 1928 a review was made of the records which had been obtained on insect activity in the upper air. It was found that

while many important data had been obtained, it was necessary to revise this work on a basis of more regular observations supported by more complete records on meteorology, as it had become evident that some meteorological factors which had not been previously considered were quite important. Consequently this work is now based on regular collections at specified times and altitudes on an all-year-round basis, to give a complete picture, and is being supported by a very thorough series of ground records.

MISCELLANEOUS

In addition to the foregoing major problems, the usual amount of attention has been devoted to the other insect pests which have required investigation from time to time. The most important of these has been the cotton leaf worm, and special studies have been conducted with the view of determining the relation between intensive poisoning of the early generations which have just migrated into southern Texas and the later-season infestation in other portions of the Cotton Belt. Evidently the increased poisoning activities in southern Texas are having a very important effect in reducing the extent and severity of migrations of leaf-worm moths. Important outbreaks of other pests, particularly webworms, cutworms, grass worms, etc., have been noted and studied and advice for control given wherever possible.

INVESTIGATIONS OF INSECTS AFFECTING MAN AND ANIMALS

This work has been continued under the direction of F. C. Bishopp, as formerly.

SCREW WORMS

Various lines of experimentation with reference to the screw worm and other blowflies which attack livestock have been continued in Texas. The chemotropic responses of these flies have been given considerable attention, and further studies have been conducted with repellent materials with the hope of finding some substance which will give more complete and lasting protection of wounds against blowflies.

Tests to determine the value of systematic trapping in screw-worm control, under range conditions involving about 150 sections, have been continued, in cooperation with the Texas Agricultural Experiment Station and local groups of ranchmen, and further evidence has been found that where such trapping is properly conducted a material reduction in screw-worm losses can be brought about. In order to increase the efficacy of traps, intensive studies are now being made of the relationship between the number of flies caught and the location of the traps with reference to shade, water, habitations, topography, etc. Different types of flytraps are being tested under field conditions, including a large box trap which has been developed in the course of the work and which it is thought will be well adapted to range conditions, as it will require less frequent servicing than the smaller conical traps now generally used.

Investigations of parasites and predators of the screw worm and other blowfly larvæ have been begun, and methods of making the natural enemies of these insects more effective are receiving consideration.

CATTLE GRUBS

Additional funds provided for work on cattle grubs during the year have enabled the bureau to undertake some new lines of investigation. A laboratory has been established at Fargo, N. Dak., near the center of a district which has remained free of cattle grubs despite frequent introduction of these insects into it. It is felt that if the factor or factors responsible for this natural control can be determined they may be utilized in combating the pest in other parts of the country. All factors which may have a bearing on this problem are being carefully studied, including the chemical and physical condition of the soil, drainage, soil temperatures, climatic conditions, farm practice, parasites, diseases, and predators. Inquiry into the distribution of the northern cattle grub indicates that this species has become widely scattered in Idaho and that it is now more generally present throughout the Northwestern States than when a similar survey was made several years ago.

The area-control operations begun in Prowers County, Colo., and Knox County, Ill., by the Bureau of Animal Industry have given an opportunity for investigating the flight habits of the two species of warble flies and to test on a considerable scale some of the insecticide treatments which in previous work have been found effective against the larvæ in the backs of the cattle. This cooperative work

with the Bureau of Animal Industry has been conducted with headquarters at Galesburg, Ill.

Further experimental work has been done with insecticides applied to the backs of the cattle, special attention being given to tobacco powders of high nicotine content and dusts containing nicotine sulphate, free nicotine, and rotenone and other materials extracted from Derris root. These insecticides show high toxicity for cattle grubs and can undoubtedly be developed to a point where they can be extensively used in control procedure.

SHEEP SCAB MITE AND GOAT LOUSE

Investigation of these parasites of sheep and goats have been continued in cooperation with the Texas Agricultural Experiment Station at Sonora, Tex., and at the Dallas, Tex., laboratory. The incubation period of the different species of goat lice has been determined and the developmental period required in each case has been determined under certain conditions. Both of these points are of distinct importance in connection with the question of the interval between dippings. A number of different insecticides, especially in the form of dips, have been tested against goat lice. Among these the very fine sulphur dusts are most promising. They are very effective in destroying the lice, and no injury to the mohair or animal is apparent.

FLY CONTROL UNDER FARM CONDITIONS

Investigations of methods of meeting fly problems under practical conditions on the farm have been continued in cooperation with the Bureau of Dairy Industry at the Beltsville, Md., farm. The practicability of controlling the horn fly, house fly, and stable fly by means of proper manure disposition, the use of kerosene-pyrethrum extract as a spray, and the operation of flytraps has been further demonstrated.

EYE GNATS

The eye-gnat problem became so acute in the Coachella Valley, Calif., that provision was made in the second deficiency bill for an investigation of that pest. The eye gnats (a species of Hippelates) are present in annoying numbers in many parts of the South, but for some unknown reason they have become extremely abundant in the Coachella Valley. They are apparently important factors in the transmission of pink eye and trachoma, and conditions with regard to such diseases have been rather serious, especially among school children. The presence of the gnats has interfered materially with farm operations and has tended to shorten the period when winter residents could comfortably remain in the infested areas. The breeding habits of eye gnats are not known, and to find the source of the hordes of these insects is one of the principal problems. It has been found that the Hippelates breed under several different conditions, though their exact host relationships have not been determined. This work is being done in cooperation with the California Agricultural Experiment Station and the Coachella Valley mosquito-abatement district. The problem is being studied in valleys adjacent to the Coachella and in Arizona and Texas for the purpose of correlating eye-gnat abundance with climatic conditions, soils, crops, and agricultural practices.

MOSQUITOES

Studies of the biology and habits of anopheline mosquitoes were continued at Mound, La., especially with reference to the measurement of the effect of various ecological conditions on larval development and abundance. These studies indicate a large degree of adaptability on the part of the mosquito to its environment.

Further studies were made with reference to the use of the airplane in controlling malarial mosquitoes under swampy conditions. In this work a test was made of the effect of airplane distribution of Paris green over all important mosquito-breeding places within a radius of 1 mile of the village. The breeding areas were dusted at regular intervals throughout the summer, the results of the dusting being noted in these areas and counts being made to determine the abundance of adult mosquitoes within the village. Although it was further demonstrated that under satisfactory flying conditions Anopheles larvæ can be controlled in a given area by the use of Paris green distributed by airplane, it was found that the work did not materially reduce the number of adult Anopheles in the village, presumably because of the limited breeding area under treatment. This work would also seem to show the necessity for treating the breeding places of malarial mosquitoes over a radius greater than 1 mile from a point which it is desired to protect. In connection with this work, studies

were made of the relative efficacy of different carriers used with Paris green in airplane dusting. The relative toxicity to several kinds of mosquito larvæ of various brands of Paris green and other poisons was determined under laboratory conditions. On account of the fact that an application of Paris green is effective in destroying only those larvæ which ingest it soon after an application, as the poison neither sinks in nor is otherwise dispersed, studies have been made in an effort to develop a poison which would be less easily wet by the water, which would retain its toxicity longer, and which would remain on the surface of the water for a considerable period after application.

In a continuation of the studies of the use of pyrethrum sprays against adult mosquitoes it was found that a home mixture made by soaking 1 pound of pyrethrum powder in 1 gallon of kerosene for a period of 72 hours gave a spray as effective against mosqu toes as any of the proprietary products tested. In tests of pyrethrum powder as a larvicide against Anopheles it was found that 1 part of pyrethrum powder to 25,000 parts of water by weight was necessary to effect Anopheles control, while 1 part of pyrethrum to 44,000 parts of water gave effective control against Culex. The use of this material in open bodies of water is further limited by the fact that it is very toxic to fish when applied in quantities sufficient to control mosquitoes.

A partial survey of the mosquito situation in Florida was made last summer, in cooperation with the Florida State Board of Health. It was found that the principal species causing annoyance in the inland lake region of the State was *Mansonia perturbans* Walk. Since this mosquito is also an important pest in many other parts of the country, and since no effective control measures have been developed, and little is known about the life history of this species, some investigations of the biology and control have been begun.

INVESTIGATIONS OF INSECTS AFFECTING FOREST AND SHADE TREES, INCLUDING THE GIPSY MOTH AND THE BROWN-TAIL MOTH

The research work pertaining to the gipsy moth and the brown-tail moth, formerly under the direction of A. F. Burgess, was transferred to this division at the beginning of the year. The work of the division, as now enlarged, has continued as formerly under the direction of F. C. Craighead, C. W. Collins being in field charge of the investigations relating to the gipsy moth and brown-tail moth, with headquarters at the bureau's laboratory at Melrose Highlands, Mass.

PINE BARK BEETLES

The destruction of western yellow pine timber in southern Oregon and northern California, discussed in the last annual report, continued with increasing severity during the spring and summer of 1928 but declined markedly in the fall of the year. The annual survey of this district revealed a total loss for the year of 261,860,000 board-feet of merchantable timber, valued at over $1,250,000. In addition to furnishing information on control to the owners concerned, these surveys are expected to give valuable information on the periodicity of outbreaks of the western pine beetle and the relation of these to climatic cycles and the concomitant fluctuations of tree vigor and resistance. Control operations are still being carried on by private timber owners, the Forest Service, and the Office of Indian Affairs on portions of the worst-infested units.

A serious epidemic of the western pine beetle in the pine forests on the Modoc National Forest, in northern California, which threatened to wipe out from 25 to 50 per cent of the stand, was met by the Forest Service, on the advice of the Bureau of Entomology, by a sale of the infested unit to a lumber company. The contract provided for the control of the beetle through logging or burning the infested material, and for salvaging the timber before deterioration. During the fall of the year the Bureau of Entomology cooperated with the Forest Service and the private operators in supervising the marking of infested trees to be removed in the control program. The company cleaned up the infestation on 17,000 acres during the fall and winter, and will be required to extend control operations to 30,000 acres during the next season. Control operations on a large scale were also carried on during the winter of 1928–29 by the Forest Service and Office of Indian Affairs in southern Oregon, involving an expenditure of about $35,000. An equal amount will be expended by private timber-owning corporations in the same district.

Research work during the year has distinctly advanced our understanding

of the factors involved in the western pine-beetle problem. Considerable attention was devoted to study of the influences, aside from artificial control work, which affect the abundance of this bark beetle. It has been found that under endemic conditions the slower growing trees are selected for attack, and that epidemics usually develop where the stand contains an exceptional number of slow-growing trees as a result of overstocking, drought, or defoliation. A study now under way of the characters of both susceptible and resistant trees, including physiological differences, will enable us to recognize these reserves of timber especially liable to heavy bark-beetle losses. It will then be possible to protect such stands by the initiation of control work at the first sign of an insect outbreak or by cutting out the susceptible trees through selective logging.

The management of western yellow-pine stands offers the most promising means of eliminating losses from this bark beetle. An experiment in marking and logging an infested area was carried out on a small scale on the Modoc National Forest in 1927, where all susceptible trees were cut. Results were checked in 1928, when it was found that the volume of beetle-killed timber was 40 per cent less than it was on adjoining areas.

Considerable progress was made during the year on the study of insects predatory upon the western pine beetle. It was found that the most important predator, *Enoclerus nigriventris* Lec., often migrates in considerable numbers during the late larval period to the soil around the base of the tree and that large numbers of these predators can be saved by preventing the burning of the stump and surrounding ground cover in control work.

The intensive investigations for the development of more economic and effective methods of combating bark-beetle outbreaks within the lodgepole-pine stands in the northern Rocky Mountains were continued during the past season. This work was located on the east fork of the Bitterroot River in Montana, where an extensive outbreak of this insect exists. Tests have been made of several methods of artificial control, some of which show promise of being economically successful, while many others have been eliminated as ineffective.

Control operations within the Big Hole Basin in Montana were again carried out by the Forest Service under the technical supervision of the Bureau of Entomology during the season of 1928. This project was started in 1926 for the purpose of preventing the spread of a serious epidemic of the mountain pine beetle in lodgepole pine and yellow pine, which for several years had been spreading south along the Continental Divide and which now threatens valuable commercial and æsthetic timber stands in adjacent national forests and in the Yellowstone National Park. This outbreak has resulted in the destruction of great quantities of timber. From 40 to 60 per cent of the lodgepole and yellow pine stands on many hundreds of square miles has been destroyed. Because of the magnitude of this infestation, it was necessary, in conducting this project, to adopt what is known as the barrier plan of control, selecting the Big Hole Basin as a zone of defense in which all infested trees were to be treated each year as long as any reinfestation occurred. This departure from the usual method, requiring the treatment of all the infested trees, made this project merely experimental, as no assurance of success could be given. It was hoped that the Continental Divide would act as a partial barrier to the spread of the beetles from the solid blocks of infestation in the Bitterroot Valley into the zone selected for defense and that it would prove possible to protect the valuable timber stands to the south by holding this area against the southward spread of the epidemic. Approximately 65,000 trees were treated in 1928 at a cost of about $95,000, and the result was a very thorough clean-up of all infestation within the region. During the subsequent summer, which was apparently an extremely favorable one for the spread of these insects, the beetles crossed the Continental Divide and swept into the zone of defense in such numbers that control work in this area had to be given up.

In planning future control work advantage will be taken of the fact that there is a rather wide strip of timberless country lying a few miles to the south of the Big Hole Basin which it is hoped will prove to be at least a partial barrier to the southern movement of this epidemic.

During the season of 1928 the Forest Service conducted two projects, under the general supervision of the Bureau of Entomology, to combat outbreaks of the mountain pine beetle within the white-pine stands of the

Kootenai National Forest in Montana. The results were satisfactory. A general increase in the activity of this insect throughout the white-pine stands of northern Idaho and Montana, however, threatens to result in serious losses of timber unless the many incipient outbreaks which now exist are controlled.

INSECT PROBLEMS IN THE NATIONAL PARKS

A forest-insect survey conducted in the Yosemite National Park showed that the red turpentine beetle was seriously injuring many of the finest yellow pine trees on scenic and recreational sites. A special study of the situation was made, and control measures were recommended.

A special survey of Crater Lake National Park in September, 1928, showed that a heavy epidemic of the mountain-pine beetle had developed on areas near the western boundary of the park and was advancing toward the areas near the administrative headquarters, where control work was completed in 1927. Approximately $17,000 was utilized by the National Park Service for control work, which was started in May, 1929, and completed shortly after July 1.

PROBLEMS UNDER INVESTIGATION IN EASTERN STATES

Cooperation with several of the Forest Service experiment stations was continued as in past years, the very limited resources permitting work on only a few of the most urgent problems, in the Lake States, in the Northeast, and in the Southeast. Progress on specific problems is reported below.

During the year the work on the spruce budworm has been confined to the collection of data on an extensive series of sample plots in northeastern Minnesota. These plots are located in an area where an infestation of this insect has been in progress for the last few years. The purpose is to show the progress of events during and following an outbreak, and to determine in so far as possible the factors involved in starting the outbreak and in bringing an infestation to a close. The infestation is now at an end, and one more field season will close this project as a major activity. Conclusions can not be drawn concerning this study until the data have been fully analyzed.

The jack-pine sawfly has been studied on a series of sample plots in and near Itasca Park, Minn. This species has not appeared in epidemic numbers during the last few seasons because of the controlling effect of weather conditions, and that of disease, which appears to be correlated with weather.

The larch-sawfly investigations in Minnesota and Wisconsin were continued during the past season and sufficient data were compiled to enable the following conclusions to be drawn:

This insect, which has only 1 male to 25 females, reproduces parthenogenetically, at least in part.

The larch sawfly is much more susceptible to high temperatures than most insects.

The development of the new growth at the time of oviposition has a distinct effect upon the number of eggs deposited by each female sawfly.

Insect predators and birds are relatively unimportant in reducing the numbers of the sawfly. Mice are extremely important and destroy on an average, in all swamps examined, over 60 per cent of the cocooned prepupæ.

Insect and fungous parasites are decidedly variable in effectiveness, but are seldom an important factor. Occasionally, however, they are very effective.

The quantity of food required to bring a larva to full growth has also been measured.

The work of introducing parasites for the control of the very destructive pine tip moth at Halsey, Nebr., showed very encouraging results during the past season. The parasite *Campoplex frustranae* Cushman, which was established two years ago, has taken hold and has increased at a remarkable rate, raising the parasitism of the tip moth in the areas where it has become established from about 20 to over 50 per cent. If this parasite continues to increase, its beneficial effect in reducing the injury of the tip moth should soon be noticeable.

In the vicinity of Asheville, N. C., a series of tests were made to determine the effectiveness of several sprays on locust-borer infestation in black locust. Mortalities of from 95 to 99 per cent were obtained with emulsions of sodium arsenite, orthodichlorobenzene, and paradichlorobenzene. It is planned to continue this work for one or two seasons longer to determine which of these sprays is most effective under all conditions.

The study, in cooperation with the Bureau of Plant Industry, on the interrelation of certain blue stains of the genus Ceratostomella and the southern pine beetle has brought out some very interesting results which may materially alter our conceptions of the pine-beetle problem. Inoculations with cultures of these fungi demonstrated that the fungi alone are capable of killing the trees and gave

further support to the theory, previously held, that the beetles inoculate the tree with these blue stains, which in turn kill the tree and afford suitable food for the development of the beetle broods. Work on this problem will be continued through the next year.

INSECTS AFFECTING FOREST PRODUCTS

Tests of wood preservatives for both crude and finished forest products, as well as poisons for wood pulp and fiber products, to prevent insect attack, have been continued. Many additional preservatives have been placed under test in Panama. In addition, in cooperation with the Forest Products Laboratory of the Forest Service, four sets of timbers, each set impregnated with 14 different preservatives, have been shipped, respectively, to South Africa, Australia, Panama, and Hawaii, where entomologists of the various local governments will make yearly examinations and report on how these preservatives protect the wood from attack by termites. During the year an inspection was made in Panama of the tests under way, and important modifications were made in the method of testing preservative treatments to protect wood from dry-wood termites. In cooperation with the National Committee on Wood Utilization and the American Wood-Preservers' Association, centers for the retailing of timber impregnated with standard chemical preservatives have been advocated, and wood suitably treated is now available for purchase by the small buyer.

To supplement the tests of wood preservatives termite-proof buildings have been built entirely of timber impregnated with standard chemical preservatives, or of termite-resistant woods common in the United States. A recent inspection of these buildings in Panama shows that to date they are proving satisfactory.

A mill-scale study on southern Appalachian hardwoods was undertaken in cooperation with the Forest Products Laboratory of the Forest Service. Only chestnut and oak were found to be subject to severe injury by insects. Black locust was also infested, but not enough timber was available for study to arrive at any definite conclusions. Poplar appeared to be relatively free from injury. Defects in chestnut lumber were caused principally by the timber worm *Melittomma sericeum* Harris, while those in white oak, and chestnut oak in particular, were caused by the pinhole borer *Corthylus columbianus* Hopk. A characteristic stain accompanies the pinhole injury, which increases the area of the defect. These defects caused a lowering of the value of chestnut and chestnut oak lumber from one to three grades. No direct loss was due to culls. In chestnut only the No. 1 common and the "sound wormy" grades were affected.

SHADE-TREE INSECTS

Studies on the control of the boxwood leaf miner by fumigation have been brought to a close during the year, and a part of the results of these experiments has been embodied in a manuscript. Some work has been undertaken to assist the forest entomologist of Maine by cooperation in the control of the birch leaf-mining sawfly, *Phyllotoma nemorata* Fall., now very abundant in New England. A large number of requests for advice on insects affecting shade trees and hardy shrubs have been handled.

Studies of the life history, economic importance, and control of insects injurious to trees of special value for ornament, shade, and recreation were continued. A study of one species was completed and published as Technical Bulletin No. 83, The Pacific Flathead Borer.

GIPSY MOTH AND BROWN-TAIL MOTH

The foreign work relating to the gipsy moth has included field investigations in Hungary, Yugoslavia, Austria, Czechoslovakia, and Poland, biological studies on certain of the parasites of the gipsy moth and the satin moth, and the shipment of parasites from these central European countries to the gipsy moth laboratory at Melrose Highlands, Mass. Two entomologists have conducted this work, with headquarters at Budapest, Hungary. A total of about 180,000 parasites were shipped from Yugoslavia, Hungary, Austria, and Poland during the summer of 1928. Approximately 3,000 of these were *Hyposoter disparis* Vier., the remainder comprising various species of tachinid flies. Biological investigations are also being conducted at the laboratory in Budapest, Hungary, in an attempt to gain more pertinent information on the host relationships of the parasites attacking these hosts in Europe.

In addition, 30,000 cocoons of the oriental hag moth, *Cnidocampa flavescens* Walk., were received from Japan in the spring of 1929. At the time of the preparation of this report

the parasites had not yet emerged from this material, but dissections indicate parasitism of about 30 per cent by a species of Tachinidae.

During the year over 3,575,000 parasites have been liberated in the infested area in the United States, over 3,500,000 of them being the egg parasites (*Schedius*) *Ooencyrtus kuvanae* How. and *Anastatus disparis* Ruschka. One of the important liberations was that of *Phorocera agilis* R. D. in large numbers from overwintering material received from Europe in the late summer of 1928. Liberations were made of fertilized females which deposited eggs upon gipsy-moth larvæ.

Recovery was made in the summers of 1927 and 1928 from two locations of a species of Apanteles, a parasite introduced in 1927 on the satin moth.

Collections from many parts of the infested territory indicate that the parasitism of the gipsy moth by the egg parasites *Anastatus disparis* Ruschka and *Ooencyrtus kuvanae* How. has slightly increased over that of the previous year. All the larval and pupal parasites also showed an increase, namely, *Compsilura concinnata* Meig., *Sturmia scutellata* R. D., *Apanteles melanoscelus* Ratz., and the predatory beetle *Calosoma sycophanta* L.

The Calosoma beetle trap was further developed during the year, and some amazing records were obtained with reference to population—as many as 65 and 52 adults of *Calosoma sycophanta* L. being trapped on each of two trees during the season and as many as 4,216 per acre in one location. Further studies are being made to note the effect of removing beetles from overpopulated areas and liberating them in new territory where the gipsy-moth infestation is light but increasing.

The parasitism recorded generally from brown-tail moth larvæ in the winter webs was about the same as that of the previous year, while the parasitism among the summer larvæ showed an increase.

In the summer of 1917 a bacterial disease of the gipsy moth, *Streptococcus disparis* Glaser, was introduced from Japan and liberated in the field by R. W. Glaser, who was then conducting investigations on the diseases affecting this host. Specimens of larvæ were found dying in the field in the summer of 1928 and, when examined, were determined as having died from this disease. Further investigations are being conducted to determine the prevalence, distribution, and economic importance of the disease.

It has been observed for some years that hibernating satin-moth larvæ are affected, sometimes to high percentages, by a fungous disease. Some preliminary investigations this year have shown that two species of fungi are present, the species encountered being both parasitic and saprophytic on insects. They are (*Sporotrichum*) *Beauveria globulifera* Speg. and a species of Isaria.

Spraying tests with lead arsenate, with fish oil as a sticker, are being continued with the object of further reducing the dosage of poison required to kill gipsy-moth larvæ. The dosage has been reduced from 6¼ pounds to 5 pounds per 100 gallons of water, with 4 ounces of fish oil to each pound of poison.

Experiments conducted this year indicate that good control may be expected by spraying with a solution of 3 pounds of lead arsenate in 100 gallons of water when the gipsy-moth larvæ are very small, and with a solution of 4 pounds per 100 gallons when they are half grown to near full grown, fish oil being used in all cases at the rate specified above. Promising results have also been secured in spraying for the satin moth, using 5 pounds of lead arsenate to 100 gallons of water and 20 ounces of fish oil. This application, made during the first two weeks in June in New England, when the larvæ are about half grown, kills the larvæ, and enough of the poison is held on the foliage to effect efficient control of the newly-hatched larvæ feeding in August and September. So far as is known, this practice of using one poison spray to kill two generations of a foliage insect with one application is new in the United States.

Dusting experiments have been continued during the year with the idea of developing a sticker for poison dusts. Among the materials tried were fish oil (17 per cent by weight), ferric oxide (15 to 25 per cent), aluminum oxide (25 per cent), and a special proprietary sticker dust. All these materials showed promise and are being tried on a larger scale.

Studies of injury to foliage resulting from the action of arsenates on the leaf suggest that much of the calcium arsenate and lead arsenate breaks down on the acid leaf surface in the presence of dew, fog, and rain. When lime is added to arsenates which are dusted or sprayed on the foliage, con-

siderable leaching out of the arsenates results.

Toxicity experiments were also conducted to ascertain the quantity of foliage eaten by the various larval stages of the gipsy moth in relation to the concentration of the arsenical. Analysis suggests that a considerable part of the arsenic passes through the digestive tract unchanged, much more being found in the digestive tract than in the remaining tissues. The quantity of food eaten was almost in inverse ratio to the quantity of arsenical deposited on the foliage, and the time required to kill varied inversely with the quantity of arsenical.

Defoliation by the brown-tail moth was extensive in southeastern New Hampshire and a small portion of southwestern Maine in 1928, as for several years preceding, but indications are that it is slightly less extensive in that section in 1929. Several small local infestations still exist in the coastal region of Maine and in the eastern section of Massachusetts.

The area affected by the gipsy moth in New England in 1928 was formidable: 142,774 acres was estimated to be from 75 to 100 per cent defoliated, and an additional acreage of 119,740 was rated as from 10 to 75 per cent defoliated, a total of 262,514 acres. The amount of defoliation for 1929 has not yet been estimated, but indications are that it is extensive.

BEE-CULTURE INVESTIGATIONS

The work of the bee-culture laboratory has continued under the direction of James I. Hambleton, with headquarters at Somerset, Md.

BEHAVIOR OF BEES

The use of the Watson method for the artificial insemination of queenbees has continued with further success, and several improvements in the technic have been made. Two papers have been submitted for publication dealing with the success achieved with the Watson method at the bee-culture laboratory.

Several thousand biometric measurements of worker bees have been made, and these will be used in an effort to determine the physical differences between different races and varieties of races of honeybees. This work will be continued until all of the principal races and varieties have been measured, and will be carried on in conjunction with the work in genetics, in which artificial insemination will be used to make all necessary matings. So far special attention has been given to the Cyprian and Carniolan bees. In obtaining some of the material for these studies the electric incubator has been used with considerable success for the incubation of queen cells.

Apparatus has been installed for exposing bees to ultra-violet rays to ascertain the effect on egg laying, behavior, etc.

A paper dealing with the results of package-bee investigations in 1926 and 1927 has been prepared and will shortly be submitted to the department for publication.

The work on the reaction of honeybees to light has been continued. The acuity of brightness discrimination of honeybees compared to that of humans has been investigated. It was found that under the conditions of the experiment many bees distinguished between two small areas illuminated with white light when one was reduced to 70 per cent of the intensity of the other. Human beings were found to be considerably more sensitive, being able usually to distinguish between the same two areas when one was made 80 per cent as intense as the other, and often when the one was made 90 per cent as intense as the other. The work on the relative stimulative efficiency of the different colors in the spectrum, heretofore confined to the visible spectrum, indicates that bees may respond to ultra-violet in a way quite different from human beings. With new apparatus this problem is to be investigated further. A manuscript in three parts dealing with the reaction of bees to light has been submitted for publication.

Another season's data have been secured on the flight activity of honeybees, which will be used in correlating flight activity with various weather factors. Duplicate equipment for automatically recording the flight activity will be installed at each field station of the division to ascertain whether there is any constancy in the reaction of bees to identical weather factors in different localities.

PHYSIOLOGY OF BEES

The study of the longevity of individual bees has been continued. The mortality of package bees is the subject of a study in which temperature, available space, type of cage, kind of food, age of bees, and effect of ship-

ping are being given particular attention. The longevity of queenbees in confinement is also being studied.

DISEASES OF BEES

Investigations dealing with septicemia of the honeybee have been continued, and a paper treating of certain phases of this disease was submitted for publication outside the department.

As a result of recommendations appearing in a number of bee journals advocating the use of formaldehyde gas for disinfecting combs infected with American foulbrood, investigations to determine the merits of the gas for this purpose were undertaken. It was found that beekeepers were not warranted in using the gas under the conditions recommended largely by amateur investigators. Serious losses were reported as a result of the use of formaldehyde gas, and in some cases attention was called to the fact that beekeepers needlessly installed expensive equipment for sterilizing combs with this gas. It was found that under proper temperature conditions dry uncapped combs could be sterilized with formaldehyde gas with relatively little trouble and expense, but that brood combs containing sealed brood cells required a long exposure. The work as a whole has not progressed sufficiently to warrant recommendations, although in response to inquiries beekeepers have been warned to uncap brood combs before subjecting them to the gas and, what is of more importance, to remove all honey. When combs wet with honey have been treated with the gas, then aired thoroughly and later given to the bees, heavy mortality has resulted. Honey retains the formaldehyde even after long intervals of exposure to the air and remains decidedly poisonous to bees. It seems probable that formaldehyde gas may eventually be used to sterilize supercombs as a precautionary measure to eradicate any possible source of infection that may exist outside the brood chambers. Two preliminary papers on this subject have been written for publication outside the department.

The routine work of examining samples of brood has been continued during the year, over 900 samples having been diagnosed. A change in the method of reporting diagnoses has been made. Hitherto it was the custom to forward to beekeepers, sending samples diagnosed as American foulbrood, a copy of Farmers' Bulletin 1084, Control of American Foulbrood, in which the shaking treatment is recommended. The office now merely notifies the beekeeper as to the diagnosis, referring him to the State inspector for further advice as to the method of eradication. Since several States now make it compulsory to burn material infected with American foulbrood, this manner of notifying the beekeepers was adopted so as not to run counter to the recommendations made by these States. It has likewise been planned to place more emphasis on burning as a means of American foulbrood control in future publications on this disease. Until burning was adopted by some States very little progress could be noticed in the eradication of the disease. All adult bees received are examined for the mite *Acarapis woodi*, the cause of Isle of Wight disease, but so far the mite has not been found in this country. During the year only 54 queenbees were imported into the United States from foreign countries.

BEEKEEPING REGIONS IN THE UNITED STATES

The study dealing with the cost of honey production and apiary management, which was started last year in cooperation with the Bureau of Agricultural Economics and beekeeping specialists in the States where the studies are being conducted, was actively continued during the year. Labor records and expense statements, as well as the methods of apiary management of some 40 cooperators in the intermountain States, were carefully studied. In all nearly 28,000 colonies were included in the survey. A preliminary report showing the progress of the first year's work has been submitted and approved for publication as a multigraphed circular. In preparing this account of the work for publication it was purposely planned to refrain from making specific recommendations as to methods of management because it was felt that the work should cover a longer period before this was done. The reports of the first year's work are intensely interesting in that they show, for instance, a variation in the cost of producing extracted honey ranging from 2 cents to 22 cents per pound. The work also plainly indicates that the average beekeeper can materially increase his profits by systematic and businesslike management of the apiary work. Arrangements have been made with some of the original cooperators to continue keeping records for a period of three years more. Plans are now being made for the expansion of

this work in other beekeeping regions where conditions are different from those in the intermountain States. This work also will be done in cooperation with the Bureau of Agricultural Economics and with the beekeeping specialists of the various States. Active work will begin this fall in the white-clover belt.

The phenological work on honey plants has been continued. It is being carried on largely through correspondence and will necessarily require several years for completion.

During the year American exporters of honey have suffered considerable loss in having shipments of honey to Germany refused at the ports of entry because they were alleged to be low in diastase. In some instances these shipments were allowed to enter, but only to be used by the baking trade, and in these cases the exporter was forced to accept a lower price. In order to minimize this loss, arrangements were made with the Bureau of Agricultural Economics, in cooperation with the Bureau of Chemistry and Soils, to conduct chemical tests on all lots of honey for which official certificates of grade were asked. Lots of honey that are given certificates will be tested for diastase and the presence of invert sugar, so there should be no question as to their acceptance by German buyers. Educational material is also being prepared for transmittal to Germany through the Bureau of Agricultural Economics, showing methods of honey production and the manner in which honey is handled in this country. Assistance was also given to some of the honey exporters who experienced difficulty in having shipments of honey accepted by the customs officials of France. Analyses by French chemists indicated adulteration with invert sugar. It was found that the honey had not been adulterated, although it was probable that it had been overheated. These shipments were eventually accepted. Samples of honey from the entire United States are being collected to be analyzed by the Bureau of Chemistry and Soils for the diastase content, as well as for other ingredients. Assistance is also being given to this bureau in collecting other samples which will be used in an intensive study of North American honeys.

DEMONSTRATIONS IN BEEKEEPING

It has been necessary to continue the refusal of invitations from beekeepers' organizations throughout the country to assist at their meetings. Many requests are made that members of the staff attend these meetings, but it is possible, because of lack of personnel and funds, to participate in only a few. Assistance has been given in helping maintain a beekeeping exhibit at the National Museum, where bees are kept in glass observation hives. This exhibit has a great educational value and is one of the most popular exhibits in the museum. The equipment other than the bees was furnished through the kindness of some of the supply manufacturers. A number of observation hives were prepared and loaned for school and laboratory use. Short manuscripts, photographs, and other educational material on bees have been furnished to the press and to feature writers.

INTERMOUNTAIN LABORATORY

The work dealing with the spread of infectious bee diseases, primarily American foulbrood, has been continued in an isolated apiary located in the Medicine Bow National Forest, 14 miles east of Laramie, Wyo. Here a very interesting observation was made, namely, that the bees unassisted entirely cleaned up the disease in a number of colonies experimentally infected with American foulbrood. Ordinarily this disease is supposed to be curable only by drastic treatment. The observations made indicate the necessity for studying the behavior of the various strains of *Bacillus larvæ*, the causative organism, as well as the question of immunity, the behavior of various races of bees towards this disease, and the effect of high, dry altitudes on the life history of the organism. Because of the unexpected developments regarding the disease in this region it has been impossible to arrive at definite conclusions as to the minimum inoculum necessary to infect a normal colony. Efforts to devise methods for demonstrating the spores of *Bacillus larvæ* in honey have been continued, and while it has been found possible to do this with honey having an abnormal number of spores, no simple and reliable method has yet been found for examining commercial honeys on a routine basis. A series of culture studies have been practically completed dealing with the determination of the minimum number of spores necessary to inoculate an agar-slant culture medium to obtain germination and growth. It was found that the quantity of the initial inoculum had

a pronounced effect on the incubation period of *B. larvæ*.

The work on the flight range of the honeybee was continued in a section of the Penrose bad lands, east of Powell, Wyo. In this experiment bees were placed at varying distances from the source of nectar, which made it possible to learn exactly how far the bees from the various colonies had to fly to obtain nectar. Rather surprisingly, it appears evident from this experiment that colonies located in and at the edge of the source of nectar do no better than, if as well as, colonies placed farther away. As a matter of fact, there was but little difference in the average amount of gain for colonies located within the nectar source and those 5 miles away from it. The optimum flight range was approximately one-half mile from the source of nectar. This particular experiment is being repeated in the hope of ascertaining why colonies at the source of nectar gain no more than those some distance away, since the location of an apiary with respect to the source of nectar is of considerable importance in commercial practice.

Studies on methods of wintering in the intermountain States were continued during the year at experimental apiaries located in the yards of commercial beekeepers, where large numbers of colonies for observation were available and where various methods of packing are being tried. Indications point to the early granulation of honey in the combs as being one of the serious causes of winter losses. There is no indication from a study of the available statistics that winter losses are being reduced. They still continue to take an annual toll of 10 per cent or more of the bees in the United States.

SOUTHERN STATES LABORATORY

The Southern States bee-culture field station was established at Baton Rouge, La., on July 1, 1928. A cooperative agreement entered into between the Louisiana State University and the United States Department of Agriculture made available to the Government without cost excellent laboratory quarters, with heat, light, water, and janitor services furnished. Besides this, a nominal fund was set aside by the university for the purchase of material and equipment for the station. The station workers are becoming familiar with beekeeping practices in the Southern States, where the problems cover a wider field than those found in most of the principal beekeeping regions of the United States. The production of package bees and the rearing of queen-bees are very important and distinct beekeeping activities in the South in addition to honey production.

Because of the large areas of nectar-producing plants available in the Southern States, and the potentialities existing there for honey production, a thorough study of the nectar sources has been initiated. The progress of this survey will be slow, as it will be necessary to ascertain the limits of the principal nectar-producing plants over a wide territory, and to make detailed observations on the behavior of these plants in secreting nectar in their natural habitats, before commercial honey production can be put on a sound basis in the Southern States. It is not at all uncommon for beekeepers to be ignorant of the source of nectar from which the bees make honey. At present there is practically no information available on the subject of southern honey plants.

In an effort to reduce the losses annually sustained by express companies and buyers of package bees the department has been asked to recommend an ideal package, together with sound instructions for shipping, care of the package on arrival, etc. Undoubtedly the sale of package bees in the North to replace winter losses and make increase would be much greater if purchasers could be guaranteed the safe arrival of shipments. Until this can be done the growth of the package-bee industry in the South will necessarily be slow and subject to considerable fluctuation. Questionnaires have been sent to producers of package bees, and a first-hand study is being made of the methods of production and shipment. In arriving at a standard cage it will be necessary also to specify methods of handling and filling, care of the package prior to shipment, and the quality of the bees, including such factors as age, race, and sex.

TAXONOMY AND INTERRELATIONS OF INSECTS

A number of important activities, grouped under this division, are carried on under the direction of the chief of bureau. These include, among others, investigations in taxonomy, insect pathology and morphology, bioclimatics, and the insect-pest survey.

TAXONOMY

Work on identification and classification of insects, a large share of

which is of the continuing type, has gone forward during this year much as in past years. Owing to the transfer of S. A. Rohwer from the taxonomic unit to the position of Assistant Chief of the Plant Quarantine and Control Administration, the administrative supervision of this unit has been in the hands of Harold Morrison.

During the year a large amount of time in all the projects has been given to the proper arrangement and organization of the collections in order to put them into condition which will permit of their satisfactory use for reference, identification, and study purposes. Considerable progress has been made along these lines, but much remains to be done before this work is completed.

During the year 11,446 identifications have been made for the various offices of the bureau, for the Department of Agriculture and other governmental departments, and for State workers and private individuals in this country and abroad. As shown in Table 1, this represents a reduction in the number of identifications made as compared with the record for the fiscal year 1928.

TABLE 1.—*Identification of insects by the Bureau of Entomology for various agencies*

Order	Identifications, 1927–28	Identifications, 1928–29
Hymenoptera	1,742	2,227
Coleoptera	2,880	2,251
Lepidoptera	2,662	1,974
Diptera	1,706	1,548
Orthoptera and Neuroptera	577	626
Ectoparasites and small orders	864	588
Hemiptera	607	567
Coccidae	2,200	1,692
Total	13,238	11,473

So far as the determinations for the fiscal year 1929 have been analyzed, this reduction appears to be due entirely to a lessening demand for identifications of extremely common insects collected by the inspectors of the Plant Quarantine and Control Administration (formerly the Federal Horticultural Board).

No changes have been made in the organization of the projects which were established during the fiscal year 1928.

In addition to the identification work, mention may be made of various developments in connection with the different projects.

COLEOPTERA

Through a special arrangement whereby the Bureau of Entomology furnished compensation for work performed, all of the available specimens of beetles belonging to the subfamily Rutelinae of the coleopterous family Scarabaeidae have been sent to Friedrich Ohaus, Mainz, Germany, a world authority on this group of insects; he has made authoritative identifications for practically all of the specimens sent to him, and these have been returned. This subfamily contains a large number of important economic species, such as the Japanese and Asiatic beetles and many others, and it is consequently very advantageous to the bureau to have available for reference these authoritatively identified specimens. When Doctor Ohaus's work is completed it is expected that the National Museum collection will be able to obtain, through exchange, additional species belonging to this subfamily which are not now represented therein.

An extensive paper on the genus Agrilus was published during the year.

LEPIDOPTERA

During the year the museum received on permanent deposit a very extensive collection of Lepidoptera from the Brooklyn Museum, and the bureau workers have been engaged in incorporating this collection in the collections of the National Museum.

Under a special assignment one of the workers on this order of insects devoted two and a half months during the year to a trip to Guatemala to investigate the reported occurrence there of the European corn borer. He has also continued his studies of the Phycitinae.

Systematic monographs covering the species of two subfamilies of moths have been prepared, and one of the specialists has worked for the entire year on a monograph of the American species of the economically important family Tortricidae; this paper is now approaching completion.

DIPTERA

The bureau's specialist on fly larvæ has recently had to handle the mosquito collections, although this has left him less time than he should have for other work. The discovery of the Mediterranean fruit fly in Florida in the spring of 1929 has greatly increased the number and importance of

the calls upon him for identification of the immature stages of Diptera.

HYMENOPTERA

Aside from routine identification work, considerable time has been spent on a critical study of the species of the genus Trichogramma in an effort to establish definitely the identity and synonymy of the species belonging properly in the genus. This work will undoubtedly prove of considerable interest to economic entomologists because of the progress which is now being made in the breeding of Trichogramma for artificial parasitization of the eggs of various economic insects. Studies of various groups of Ichneumonidae have been continued.

ECTOPARASITES AND MITES

In connection with the work on mites, much time has been devoted to the completion of a study of the classification of the feather mites, which was begun by another worker some years ago.

COCCIDAE

A monographic classification of the Margarodidae was issued during the year, and work is being continued in the organization of the collections and notes in such fashion that critical studies can be pursued whenever time permits.

CREEPING ERUPTION AND CANINUM DERMATITIS

The investigations made during the past few years by G. F. White and W. E. Dove on creeping eruption and those recently made by them on caninum dermatitis, which were carried out by this bureau on an understanding with the Bureau of Animal Industry, have been brought to a close. Creeping eruption is a disease of the human skin caused by infective larvæ of the hookworm *Ancylostoma brazilicnse*, which infests dogs and cats. Observations on the common dog and cat hookworm, *A. caninum*, have shown that larvæ of it, too, can invade the human skin and cause itchy papular lesions that resemble early symptoms and lesions of creeping eruption. The advancing linear lesions that characterize later stages of creeping eruption, however, have not occurred in experimental infections with *A. caninum*. Several papers relating to these investigations were published during their progress, and another has been prepared and accepted for publication.

INSECT PATHOLOGY AND MORPHOLOGY

Work on problems relating to the diseases of insects that were being studied by G. F. White during the preceding year has been continued. Increased attention has been given to the polyhedral diseases. It is expected that the work on potato-beetle septicemia will soon be sufficiently rounded out so that a manuscript report on the disease can be submitted.

The results obtained by R. E. Snodgrass in the study of the morphology of various types of insects are of importance to entomologists generally and have a special bearing on toxicological experiments. Reports have been issued, entitled "The Morphology and Evolution of the Insect Head and Its Appendages," "The Mind of an Insect," and "Some Further Errors of Body-Wall Nomenclature in Entomology." A manuscript is ready for publication on The Thoracic Mechanism of a Grasshopper and Its Antecedents, and papers are in preparation on How Insects Fly and on The Sucking Apparatus of Hemiptera, Lepidoptera, Hymenoptera, Diptera, etc.

BIOCLIMATICS

Research in bioclimatics has been carried on since July, 1923, at the bureau's field laboratory located at Mineralwells, W. Va., under the direction of A. D. Hopkins, with one assistant. The plan of procedure in the work has been to develop fundamental laws and practices relating to the phenomena of life, climate, seasons, geographical distribution, etc., as affecting local, regional, or continental agriculture and other human interests, which will be of use to the specialists in other branches of science; and to investigate and verify by general and specific tests cognate systems and methods. Most of these results are more or less new in original viewpoint and in methods of development, interpretation, and application. This work has now progressed to a stage where it is believed that a manuscript on bioclimatics may in the near future be prepared for publication.

INSECT-PEST SURVEY

The insect-pest survey has now been functioning eight years and from its inception has been under the direction of J. A. Hyslop.

Cooperative arrangements for carrying on this work are in operation in all States having organized entomological activities. By informal arrangement information is obtained concerning entomological conditions in Haiti, the Hawaiian Islands, the Dominion of Canada, and Mexico. Exchange is made of information about outstanding features with the Dominion of Canada, Mexico, and the Hawaiian Islands, which have local surveys patterned along the lines of the insect-pest survey of the Bureau of Entomology.

In addition to issuing the Insect Pest Survey Bulletin, which during the year completed volume 8 and the first four numbers of volume 9, totaling 568 pages, the survey has functioned in supplying detailed distribution records to offices and field stations of the Bureau of Entomology and to the Plant Quarantine and Control Administration.

The work of incorporating in the files the statistical data on both North American and foreign insect pests from literature has progressed as rapidly as possible with the personnel available. The survey files now contain about 78,000 notes representing 3,200 genera.

The project inaugurated last year of cross indexing the entire records under the host-plant names is now approximately half completed. This phase of the work will be of considerable value to taxonomists in determining insect larvæ from unusual host plants or from regions with which they are not familiar, because, when this work is completed, it will be possible to ascertain immediately all of the insects that have been recorded as feeding on a given plant in any country or State.

During the year the survey encouraged and assisted in the organization of State surveys in three of the Middle Western States. This work has been highly successful, even more so than was anticipated. Aside from the benefits felt by the entomological departments of the States themselves, it has augmented the mass of material which the Federal insect-pest survey is receiving from these States. The success attending the organization of State surveys demonstrates the practicability of establishing such work even where practically no additional funds are available for that purpose, as the work can be made incidental to the regular routine of the office.

One of the Middle Western States, which has very extensive and complete records over a long period of time, has made all of its back records available to the Federal insect-pest survey, and the work of copying these records and placing them in our permanent files is well under way.

During the year a technical assistant was added to the personnel of the survey, and he is bringing together climatological, geological, geographical, and botanical data to be used in attempting to explain the distribution and periodical abundance of insect pests.

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REPORT OF THE CHIEF OF THE OFFICE OF EXPERIMENT STATIONS

UNITED STATES DEPARTMENT OF AGRICULTURE,
Washington, D. C., August 1, 1929.

SIR: I have the honor to transmit herewith a report of the Office of Experiment Stations for the fiscal year ended June 30, 1929.

Respectfully,

E. W. ALLEN, *Chief.*

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

The Federal appropriations for the State agricultural experiment stations have nearly trebled in the last four years. This has greatly increased the responsibilities and extended the activities of the office in its relationship to this system of organized research. The relatively new lines of research encouraged by the increased appropriations and the policy of conserving the funds used in the older lines to new research of substantial character have called for a type and amount of attention not heretofore exercised. The enlarged relationships have brought the office more definitely than ever before into the experiment-station system and have increaed the expectations from its administration.

THE FEDERAL APPROPRIATIONS

During the year each State received for its experiment station the sum of $80,000 from the Federal Government. This was a total of $3,840,000 for all the States, representing an increase of $480,000 over the appropriation for the preceding year. This increase was in accordance with the authorization of the Purnell Act, which provided $10,000 additional to each State for the year in question, and brought the total appropriation for the year under that act up to $2,400,000. The additional funds made possible further development of research in numerous directions and contributed toward the rounding out of the programs under that act.

The remaining allotments were derived under the Hatch Act and the Adams Act, each authorizing an annual appropriation of $15,000 to each State, or a total of $1,440,000. As in the past, the Federal funds were very liberally supplemented by contributions from the States. In four years the State appropriations have increased about 50 per cent, practically paralleling the increase in the Federal appropriations. This indicates that the Purnell Act, instead of relieving the States of their obligations and resulting in decline of appropriations from that source, has had the effect of stimulating the local support of the stations, so that in the aggregate they have received twice the amount carried by that act.

The Purnell fund has been used in large measure for investigation, most of it new, and has been drawn on to a relatively small degree for providing land, buildings, and overhead expenses. Under the policy urged by the department the States have provided mainly for the capital expenditures, and administrative expenses have not been allowed from either the Adams or Purnell funds. A number of important additions to buildings and plant from which the stations will profit were completed during the year, and others looking to the more adequate meeting of the needs of research were authorized.

All told, research at the experiment stations now has become a $15,000,000 enterprise, with a force of fully 3,000

persons—the largest organized research enterprise undertaken anywhere in any line. Although made up of separate State units which have their own autonomy and responsibility, to a very large extent the stations constitute an integrated, coordinated system, united under Federal support and through the centralized clearing house which the office supplies.

To a considerable extent, responsibility for the successful functioning of this system rests with the Department of Agriculture, not alone because of its administration of the Federal funds but its advisory relations and the assistance it is expected to supply as the central agency. The duties and responsibilities imposed by the station acts result in the determination of policies and procedure which are applied to the whole organization, and the cooperative relationships in research between the department and the individual stations serve to enlarge this influence. The department is charged not only with the administration of the funds under the three experiment-station acts but is directed "to furnish such advice and assistance as will best promote the purposes of this act" (i. e., the Hatch Act, on which subsequent legislation is based), and to coordinate the research in the respective lines.

The office is also in direct charge of the experiment stations in the Territories and outlying possessions, the appropriations for which are made to this department. The funds for their support during the year aggregated $246,400, the range being from $25,000 each in Guam and the Virgin Islands to $85,000 in Alaska. A brief report on their administration is given later (p. 7).

PROJECT RECORD

During the year there were 443 active projects at the State stations under the Adams fund and 1,105 under the Purnell fund. This is a considerable increase in the number of projects under the latter fund. The Hatch fund is not as definitely restricted to individual projects as are the other two funds, but is used to some extent for administration and general overhead expenses, and is merged with other resources of the stations in the maintenance of experiments and investigations.

As a result of the year's work, numerous projects were completed or brought to a stage where new aspects led to their restatement; and a considerable number of new ones were inaugurated to replace those completed or to develop the work as permitted by the increase of appropriations. Thus there were 58 new projects or restatements under the Adams fund and 244 under the Purnell fund. All of these required careful scrutiny, often with correspondence regarding their character and features, and at times modification before being approved as part of the research programs.

It is interesting to note that during the year under consideration, 24 Adams fund projects and 106 Purnell fund projects were completed or brought to a point where they were terminated. This is an evidence of progress, and an indication that while research is not being hurried and is given opportunity to follow its necessary course, projects are so constituted as to look toward completion and accordingly are framed with definiteness and reasonably limited range.

Careful attention to details is required to keep the project lists and the budgets corrected up to date. These are based on extensive correspondence and reports covering long periods, and errors result in confusion not easily corrected. Much credit is due George Haines for the reliability of these essential records.

SUPERVISORY RELATIONS

As in the past, detailed attention has been given to the Federal funds and the work under them. Research projects on which the Adams and Purnell funds are to be used are carefully examined in advance, with particular attention to definiteness of aim and purpose, the relation of the proposed experiments and investigations to those carried on elsewhere and to the general status of knowledge, and the adequacy of the means to be employed.

Relation with approved projects is further maintained through an examination of the work and expenditures on the ground. An official visit is made to each of the experiment stations annually, frequently referred to as the "inspection," although the occasion is one for review and consultation rather than for investigation or inspection in the sense of regulation. The review of each of the projects with the leader or person in immediate charge affords a close insight into the course and progress of the individual undertakings, with opportunity to judge of the aims and motives and to

determine the success and the degree of activity in their prosecution.

The examination of approved projects is thus followed up in their actual prosecution. Progress is looked for on the individual projects, not alone in the acquisition of results but in the opening up of the subjects to a clearer insight of their nature and the means for their effective study. Since a definite objective does not necessarily imply a fixed-routine procedure, the expectation is that the investigation will express the element of inquiry in a critical examination of the data as to their adequacy and the means of securing more effective advance. Progress depends on this. Expectancy is stimulating. Research in which the viewpoint does not change from one stage to another, or the means of attaining the objective advance as the data accumulate, may suggest a lack of study and imagination, and indicate that the process has become stereotyped and routine.

ADVISORY SPECIALISTS

The judgment and comments of those engaged in the station examination are sought and invited by directors. To form such a critical judgment, and to be able to commend where warranted and to offer impressions and suggestions where called for, requires at least a general knowledge of the subject matter covered by the station projects and an appreciation of the requirements for research in them. Obviously the more intimate this understanding the better. While the essential principles apply in all fields of research and the layman may acquire insight which will serve him over a wide range, the advantage is manifest of having the aid of specialists in this task who are thoroughly familiar with their respective fields, the status of investigation, and the most effective methods of research in them.

Several such specialists have been provided in the office, whose advantage in dealing with the matters which come up to it for decision is manifest. It supplies a type of leadership which has been needed, not as directive but as advisory and for assistance when requested. The step has met with the approval of station executives and investigators in the respective lines. Home economics has received the attention of Miss Sybil L. Smith, who has established a place for herself in close and cordial relations with workers in that field. R. W. Trullinger has maintained close contact with the field of agricultural engineering, and promoted the development of research in it, both as an independent subject and as an important adjunct to other special lines of inquiry. George Haines, in charge of project records, is a specialist in genetics and recently received his doctor's degree in that field. In addition, the department editors on Experiment Station Record have rendered important assistance as far as their time permitted.

For some time efforts have been under way to provide similarly for agricultural economics, and, if possible, for rural sociology also. The importance of this is apparent from the attention which research in agricultural economics is receiving, and its relative newness in the station program. Fortunately such provision has now been made. Eric Englund occupied the position for several months, but on his transfer to another branch of the department an interim intervened before a successor could be secured. In the spring B. Youngblood was transferred to the position from the Bureau of Agricultural Economics, which is regarded as especially advantageous. The workers in rural sociology have been very urgent that a specialist in that field be added to the staff of the office, to help in its development as a research subject and in the organization of research projects under it.

These subject-matter specialists have an important part in the examination of projects with a view to their approval or modification, and in the general promotion of the ideals of sound research in their respective branches. The calls upon them by directors and members of the station forces have been extensive, and much appreciation has been expressed of their counsel and their stimulating influence. The demonstration of their importance has led to the request for an expansion in this small force to include specialists in other subjects, some of which are in the formative stage and others in which the work is in need of critical study, to free it of conventionalities and stimulate progressive research.

It is not expected that every branch of agricultural science will be covered, but the present magnitude and character of the station enterprise emphasizes the importance of a small group of well-trained specialists in the leading subject-matter branches. These must obviously be the peers of the specialists in the stations, competent to

analyze and to make constructive suggestions, and thoroughly abreast of their subjects as to status and technic. In addition to this equipment they should have the opportunity to study the research problems and the progress made in them, from a national viewpoint. There is believed to be no greater opportunity for helpful service and influence in the research field.

FUNCTION OF ADMINISTRATION

From the nature of research, its personal qualities, and its institutional relationships, administration is quite as much a matter of sympathetic encouragement and influence as of official oversight. The guiding principle in the administration of this large grant is to conserve the funds for research of appropriate grade and kind, by upholding its standards and stimulating policies and conditions favorable to it. Such administration implies far more than the examination of accounts and the perfunctory approval of projects, nor does it relate solely to the Federal funds, because these are so intertwined in their use with moneys derived from State sources.

The experiment-station system is a cooperative one involving the Federal Government and the States, and the office serves the system at large, so far as it is able.

It is an interesting fact that to a very considerable extent the State appropriations have been combined with those from the general Government in the joint support of projects, and that accordingly there is no sharp division between the employment of the State and the Federal funds. The standards for use of State and Federal funds are largely uniform; the grade of work does not differ in essential degree. This union of funds and activities emphasizes the cooperative nature of the enterprise and tends toward a more unified system.

This merging of interests within the stations has noticeably increased since the coming of the Purnell fund, and tends to enlarge the range of supervision exercised by the office and the extent to which its assistance is sought. Many projects supported mainly from State sources are made to conform to the Federal requirements by being placed in small part on one of the Federal funds. Sometimes the reason for such joint support is frankly explained as the desire for criticism to meet the Federal standards. At all events, the practice has come voluntarily, without suggestion from this office, and is decidedly on the increase.

For example, a project estimated to cost over $6,000 was submitted with the provision for only $1,200, or 20 per cent, from the Purnell fund. In another case the proposal of a $12,000 project called for only $3,000 from the Purnell fund. Another to receive $6,000 from the State assigned only $1,800 from the Purnell fund, and another with $4,000 of State funds proposed a contribution from the Purnell fund of $1,500. In the case of many projects, State funds are contributing one-half or more of their support, but the use of Federal appropriations subjects them to the same examination and approval as those supported entirely in that manner.

This combining of funds does not mean that there is not a strict accounting for each of the Federal appropriations, but it means that the standards and the supervision of the office are extended more widely over the station program, and the contact of the office correspondingly enlarged. While theoretically its supervision is confined to the Federal appropriations and the activities under them, and it has no direct authority over State funds, in practice sharp distinctions can not always be drawn on the basis of funds. The question of adequacy of support arises with reference to each project submitted or carried on with Federal funds, and the extent to which Federal support is to be supplemented becomes a definite consideration.

POLICIES AND DEVELOPMENTS

Innumerable questions arise in reference to an enterprise of this size. There has been disposition to refer such queries to this office for opinion, and to look for study by it where necessary. Many of these questions are new and involve matters of good policy rather than law in the conduct of station affairs, the organization of research, relationship of its personnel, obligations to the State, etc. Beyond this, the office itself must have policies and recommendations for the advancement of the stations. These come into effect gradually, not by insistence, but by recognition of merit. Some of these changes are quite far-reaching.

More and more the research programs of the individual stations are becoming the product of design rather

than of chance circumstances. They represent constructive planning rather than the result of contingencies. It is necessary to hold sufficient funds in reserve to meet ordinary emergencies, but beyond this, the programs are being based in large degree on the more important needs of the agricultural industry, as developed through intimate contact with it and study of the most effective means of permanently satisfying those needs. This relieves the programs of a fragmentary, fortuitous character, and makes them a reasoned product with more permanent outlook. The range of vision is beyond the present questions for which immediate answer is asked, and looks to sufficient permanence of thoroughgoing investigation to furnish sound deductions and understanding.

From the nature of the subjects now presented, more intensive and fundamental scientific work is indicated, to provide not only empirical facts but an understanding of their relationship and meaning, on which knowledge rests. This implies greater emphasis on fundamental inquiry in the sciences related to agriculture.

The office has consistently stressed this aspect of the station work in its dealings with new projects and those already under way. It has encouraged attempts at more far-reaching aims, directed not merely at securing results but at building knowledge. It has discouraged and declined to accept proposals involving little more than demonstrations of verified facts to new localities, or comparisons supplying no permanent factors or results, It has questioned the research value of surveys which aimed merely at descriptions or tabulations of current conditions as ends in themselves, and has declined to accept projects directed purely at personal service. Data which have neither any permanent value nor any proposed temporary use as a means of studying trends and relationships, and those which add only to the volume of results obtained under conditions which may never recur in the same combination, are strongly discouraged as unscientific and not properly belonging to research. Emphasis is laid on the use to be made of data in establishing some new general fact or enabling an intelligent generalization, as distinguished from the indiscriminate accumulation of information as a possible adjunct to research later on.

The drawing of such lines of discrimination needs to be accompanied by constructive suggestion which will stimulate more thoroughgoing effort. Arbitrary refusal to approve projects capable of being strengthened might easily defeat the purpose of promoting research of more advanced type. Obviously uniform standards can not be maintained for all branches, but the essentials can be made clear and the purpose strengthened.

The policy of encouraging members of the station staff to go away for advanced study or in order to make contacts with the work and methods in their respective fields is on the increase at the stations, with the approval of the office. The necessity for thorough preparation and for a progressive attitude in order to advance the research efforts is increasingly evident. To some extent the stations must still assist in training their workers and make conditions favorable for the continued growth of the workers.

COOPERATION AND COORDINATION

Plans for carrying on investigation on subjects of regional or widespread importance have gone steadily forward. The increase has been especially noticeable between the bureaus of the department and the stations. Such cooperative projects are handled through this office, which examines the plans and keeps a record of the undertakings.

At the close of the year, there were 950 active cooperative projects between department bureaus and the stations. On the basis of an approximate total of 7,000 projects at the stations, these cooperative features represented something over 12 per cent of the total number.

The largest number of cooperative agreements was with the Bureau of Plant Industry, involving 309 projects with 43 stations on subjects relating to field crops, horticulture, and plant diseases. The second largest number was between the Bureau of Agricultural Economics and 46 stations, applying to 255 projects on different features of agricultural economics and rural sociology. The Bureau of Animal Industry had cooperative agreements with 38 stations on 124 research projects.

Every bureau of the department engaged in research was included in these cooperative undertakings, which likewise included all the experiment stations. Of the latter, California led with 47 projects, North Carolina had 45, Washington 39, Minnesota 36, Virginia 32, and Wisconsin 25.

The above does not include several undertakings in progress of a regional character, involving cooperation on a less formal basis. Prominent among these are the investigations on corn improvement by the Bureau of Plant Industry and 12 stations, the study of the quality and palatability of meat by the Bureau of Animal Industry and 26 stations, the corn-borer control work, and various other enterprises.

Close relations have been maintained with the joint committee of the Association of Land-Grant Colleges and Universities on projects and correlation of research, and the chairmen of the committees dealing with the national cooperative projects have been kept informed of new projects entered upon by individual stations in order to assist in the organization of their subjects. Several meetings of these national committees and conferences of investigators on cooperative projects were held.

The office cooperated with the committee of the Social Science Research Council engaged in the preparation of manuals on research and methodology in that field.

HANDLING STATION FUNDS

Several of the State governments have taken over the handling of all experiment-station funds, including those derived under Federal appropriations. This is mainly in connection with newly enacted laws which have consolidated all disbursements and accounting at the State capitol. In a number of cases the new systems put into effect have required retention in the office of the State treasurer of all original vouchers and evidence of payment.

This arrangement does not meet the necessities of the department in the annual examination of the accounts and expenditures, which must be made in connection with the projects to which they apply. Attention has been called to this through a circular letter, and steps taken toward the installation of procedure which will correct the difficulty. The matter is still under consideration in several of the States, but it is anticipated that means will be devised which will meet the department's requirements, or that the State laws will be modified.

The suspension of funds to the Oklahoma Experiment Station at the beginning of the fiscal year resulted in their being held for several months before conditions were restored which warranted certification. When this point had been reached, an adverse ruling of the Comptroller General prevented payment of the funds, it being maintained that the acts called for certification on or before July 1, and that it could not be made at a subsequent date, the prescribed procedure being to report the matter to the President and leave the matter to the action of Congress. That body accordingly authorized the certification of the station, and the payment of the funds due it for the fiscal year was made March 16, 1929, the allotment for the first three quarters of the year being paid in a single installment.

CONFERENCES AND CONTACTS

Conferences, meetings, and service on various important committees relating to research have required an increased amount of time and attention. A number of members of the office force took an active part in such activities during the year.

The relations with the Association of Land-Grant Colleges and Universities pertained especially to the work of two standing committees—the joint committee on projects and correlation of research and the committee on experiment-station organization and policy, the chief of the office continuing to serve as secretary of both these committees; and with the section on home economics. Papers by various members of the staff were presented at the annual convention of the association in November, 1928, one on Administrative Responsibilities in the Functioning of Research, by E. W. Allen; one on Promising Lines of Agricultural Engineering Research, by R. W. Trullinger; and papers on Progress and Problems in Home Economics Research, and The Status of Purnell Research in Home Economics, by Sybil L. Smith.

Close contact was maintained by Mr. Trullinger with the American Society of Agricultural Engineers. He served on the research committee of that society and presented three papers at its annual convention, relating to research in different branches of the subject with suggestions for profitable lines and methods of study, and a paper at a conference of officers of that society entitled "Suggestions for Strengthening Agricultural Engineering Research."

Similarly, Miss Smith worked closely with the American Home Economics Association, being in charge of the

program of one of its meetings on current research in foods and nutrition, and in another presenting a review of the present scope of home economics research and the improvement of the quality of such research. At the instance of the Bureau of Home Economics, Miss Smith also completed a compilation on Vitamins in Food Materials, bringing together the determination of vitamin values from all available sources, probably the most complete assembly of such data. This was accompanied by a text relating to the different vitamins and an elaborate bibliography. The manuscript is to be published jointly with the Bureau of Home Economics. She also compiled a list of active projects in home economics and of published reports on research in that field, for which there has been widespread demand.

The chief of the office continued to serve as chairman of the editorial committee of the Journal of Agricultural Research.

George Haines assisted in a survey of animal-breeding investigation in progress at the experiment stations, and in the preparation of a report to a committee of the National Research Council.

The office was represented by H. M. Steece in the conference on weed prevention and control, held under the auspices of the Chamber of Commerce of the United States, a summary account of the weed projects in progress at the experiment stations being presented.

The office took part in a survey of existing provisions for agricultural advancement in North Carolina, made at the request of the governor of the State. B. Youngblood served as chairman of a committee of four, designated by the department, and drew up the report. Special attention centered in the organization of the research, the relation of the State department of agriculture to that function, and the desirability of a clearer recognition of the field of the agricultural experiment station, with adequate provision of facilities and funds.

A small exhibit was prepared by J. I. Schulte for the Seville International Exposition, relative to the system of agricultural experiment stations in the United States.

INSULAR STATIONS

The agricultural experiment stations in Alaska, Hawaii, Porto Rico, Guam, and Virgin Islands have continued to be under the administrative charge of Walter H. Evans. The stations are seeking to develop and diversify the agriculture of their respective territories, and they have demonstrated their value in this respect. In Hawaii, experiment stations are maintained by the sugar and pineapple industries that serve their interests, and in Porto Rico there is an experiment station operated by the local Government, but the work of the insular stations in those territories is so organized as to serve individuals and interests not cared for by local stations. In Alaska, Guam, and the Virgin Islands there are no other institutions that are investigating agricultural problems.

There were comparatively few changes in the personnel of the several insular stations during the year. J. C. Wingfield, a graduate of Kansas Agricultural College who was formerly with the Alaska stations, was appointed assistant horticulturist at the Matanuska (Alaska) station, and G. A. Roberts, formerly connected with the North Carolina Experiment Station and later with a veterinary institution in Brazil, was appointed animal husbandman and veterinarian of the Virgin Islands station. R. A. Goff, extension agent for the Island of Hawaii, and Mabel Greene, boys' and girls' club leader, were transferred to the extension service of the University of Hawaii.

The insular stations continued to be undermanned and inadequately equipped for work along many important lines. As has been previously pointed out, their sole support is derived from appropriations made by Congress, but their appropriations have not kept pace with the Government's increased contributions to the State experiment stations. The total incomes of the several stations for the fiscal year ended June 30, 1929, were as follows: Alaska, $85,000; Hawaii, $54,940; Porto Rico, $56,460; Guam, $25,000; and the Virgin Islands, $25,000. The proceeds from the sale of products, which are not available for station uses but are deposited in the Treasury as miscellaneous receipts, were $6,290.84.

The buildings and other property of the Porto Rico and the Virgin Islands stations were badly damaged by a hurricane, which swept the islands on September 13, 1928. Temporary repairs were made immediately after the storm, and the work of restoration was practically completed by the end of the fiscal year. An emergency appro-

priation of $12,500 made by Congress on March 4, 1929, $3,100 transferred from the Office of Experiment Stations, and several hundred dollars from the current funds of each station, were expended in restoring the property.

The work of the Alaska stations has been rearranged somewhat. The livestock investigations at the Fairbanks, Matanuska, Kalsin Bay, and Kodiak stations have been placed in charge of the animal husbandman of the Matanuska station. The livestock work formerly carried on at the station near the village of Kodiak has been discontinued and the cattle transferred to the Kalsin Bay station, some 15 miles away, where they are now being maintained under range conditions to ascertain their winter requirements. Data secured in this experiment should be applicable to a large area in southwestern Alaska with somewhat similar climatic conditions.

Congress, in an act approved February 23, 1929, extended the Hatch Act to Alaska, with a proviso that no appropriations should be made under the act until the Secretary of Agriculture should determine the ability of the Territory to make effective use of the funds. Since the turning over of the Federal station at Fairbanks to the college was proposed a territorial appropriation was deemed necessary to provide for badly needed buildings and to carry forward the work when the department withdraws. A bill was introduced in the legislature at its recent session that would meet the conditions laid down by the Secretary of Agriculture, but it failed of passage.

The Hawaii station has discontinued the extension work in agriculture that it was authorized to conduct beginning in 1915. The extension of the Smith-Lever Act to Hawaii and the organization of agricultural extension work under the University of Hawaii made it desirable for the station to cease extension work and to confine its efforts to research on agricultural problems. During the 14 years that the station was engaged in extension activities, a basis was established for work by homesteaders and others who were engaged in what is locally known as "small farming" as contrasted with the plantation system of operation. The interest of the youth of the islands was aroused to agricultural activities, and many flourishing boys' and girls' clubs were organized. Under the reorganization the same lines of work were continued and extended by the personnel transferred from the station.

By an act of Congress, approved May 16, 1928, the Hatch and supplementary acts giving support to agricultural experiment stations were extended to Hawaii, with some limitations, effective July 1, 1929. By agreement between the Secretary of Agriculture and the president of the University of Hawaii, the work to be carried on under the funds granted to the Territory is to be merged with the work of the station established by this department in 1901. The two institutions have been integrated into a single one under the immediate charge of the director of the Federal station. The new station, which is to be known as the Hawaii Agricultural Experiment Station, will derive its support from appropriations made to this department for continuing the research in tropical agriculture, funds granted to the Territory under the above acts, and appropriations made by the local legislature.

This arrangement will permit of considerable extension of research on the fundamentals of tropical agriculture, and also the investigation of some local problems that the former station was unable to undertake through a lack of funds. The new institution has started off very auspiciously and, with the local support that is now assured, progress should be made on problems that are of interest not only to Hawaii but to other tropical regions. In order that studies of wide application may be continued, the direct appropriations hitherto made for the support of the station should be continued and increased as the work develops. The arrangement just put into effect offers a splendid opportunity for extending some of the department's investigations into strictly tropical fields.

After the hurricane of September 13, 1928, the Porto Rico station rendered very efficient service in aiding in the restoration of the agriculture of the island. Investigations which had been carried on for many years with coffee indicated the means to be adopted for the most rapid restoration of the plantations. Advice was freely given, and many activities were directed by the station staff that assisted very materially in putting the plantations on the way to early production. Citrus planters were also assisted in saving their orchards by suggestions and demonstrations as to the raising of trees blown over in the storm, staking and pruning them, and applying fertilizers to promote rapid growth. Im-

mediately following the storm a survey was made of the losses experienced by the citrus and pineapple industries, and the data were made available to the Porto Rico Hurricane Commission.

The Virgin Islands station has added an animal husbandman and veterinarian to its staff. Such an appointment had been desired by this station for several years, and it had been recommended by several governors of the islands as a means of promoting an important industry, but funds were not available for the purpose. The appointment was made effective June 1 to meet a situation that had arisen relative to the shipment of cattle from the Virgin Islands to Porto Rico. The livestock shipments had become quite important, as Porto Rico does not supply its needs for beef cattle. For a number of years shipments were freely permitted, but late in 1928 they were stopped on account of quarantine regulations. Both the Virgin Islands and Porto Rico are tick infested, but the wording of the law would not permit shipment of cattle unless they were dipped prior to shipment and were accompanied by a certificate showing that they were free from ticks. There was no veterinarian in the Virgin Islands who could attend to this matter, and its importance was thought to be sufficiently urgent to warrant the appointment of such an officer, although to do so other work had to be curtailed.

It is hoped that the limitation of the other activities will be only temporary, as the crop work is of vital importance to the welfare of the people. Interest was just being aroused in vegetable growing to supply local needs and for shipment to New York during the winter season, but there is much experimental work yet to be done before the industry is firmly established.

The Guam station is in need of larger appropriations for buildings, equipment, and personnel to carry on its work in an efficient manner. The funds allotted to this station have never been adequate to provide for suitable salaries, buildings, and equipment. As a result many makeshifts have had to be adopted that were highly unsatisfactory and very expensive in the long run.

PUBLICATIONS

The character of the publications of the office did not change materially during the year. Thirty-two separate documents were issued, aggregating 2,500 pages. This represents a small decrease both in number of documents and in volume, owing to the limitations of printing funds.

In addition to the usual numbers and indexes of Experiment Station Record the publication list included an annual report on the work of the office, and a report to Congress on The Agricultural Experiment Stations, 1927. The report for 1928 was prepared and presented during the spring, but its publication was necessarily delayed. A bulletin was issued giving a revised list of workers in the State agricultural colleges and experiment stations, and two articles were published in the department Yearbook. Eight publications were issued relating to the work of the insular experiment stations.

EXPERIMENT STATION RECORD

During the year volumes 59 and 60 of Experiment Station Record were brought promptly to completion, under the editorial management of H. L. Knight. Each volume included the usual nine numbers, each of 100 pages of text material, and an index number.

Beginning with volume 60, however, the detailed table of contents and the list of station and department publications reviewed were replaced by an abbreviated table of contents showing merely the location of each of the 20 sections into which the abstracts are classified. This change was adopted entirely as a matter of economy. For some time the steadily advancing cost of printing has worked havoc with publications operating on fixed budget allowances, since a dollar no longer possesses its former purchasing power. In the case of the Record the discrepancy had reached something like 10 per cent.

Various remedies for this situation were carefully considered, and of these the alternative of dispensing with the 10 to 12 pages per issue of prefatory material was resorted to as the least objectionable expedient. Sacrifice of text material was thereby avoided, and while considerable inconvenience and loss of time inevitably result in consulting the current issues, this largely disappears when the index number becomes available. No change was made in this index number, and as the table of contents was customarily eliminated in binding, the bound volumes are precisely the same as formerly in size, content, and appearance.

The 1,800 pages available for text material as usual were utilized largely for the publication of abstracts reporting the results of research in agriculture and related fields, but supplemented by the customary monthly editorials discussing the promotion of agricultural education and research and related questions and by brief news notes in each issue on progress in this and foreign countries.

Although the space available for abstracts was undiminished, their total number dropped to 6,408, a reduction of approximately 10 per cent from the previous year. This change to fewer and longer abstracts was occasioned largely by the increased amount of important material published by the experiment stations under their rapidly expanding program. It has meant, however, a corresponding reduction in the space available for abstracts of the research by other agencies, although this has likewise continued to increase in scope and importance. Such conditions make the problem of an adequate review of the literature not only difficult but increasingly acute.

Considerable progress was made on the preparation of another combined subject index of the Record, to cover issues subsequent to volume 40. The publication of such a combined index, however, must be deferred until special funds are available.

Under the arrangement described last year, carbon copies of all Record abstracts of the publications of the United States Department of Agriculture and the State agricultural experiment stations were periodically transmitted to Biological Abstracts. At the close of the fiscal year the first of this material was beginning to appear in this world review of general biological literature.

LIBRARY AND BIBLIOGRAPHIC WORK

The office has continued to maintain a library in cooperation with the Extension Service for assembling and keeping complete files of the experiment station and extension publications of the country. In that connection considerable bibliographic work has been done for both offices and for the experiment stations. The library has an important relation to the work of these two offices.

A fourth supplement to the List of Bulletins of the Agricultural Experiment Stations, with author and subject index, was prepared and is nearly ready for publication. A list of circulars or less formal publications issued by the experiment stations since their organization is being compiled and is well on the way toward completion. Record is being kept of the titles of articles reporting the results of experiment-station work which are published in scientific and technical journals. This is an interesting and useful supplement to the bulletins and reports issued from the stations.

A selected list of references on agricultural and home-economics extension in the United States was prepared, which was issued by the department library in its series of Bibliographical Contribution. Other bibliographies on subjects of interest to extension workers were compiled.

U. S. GOVERNMENT PRINTING OFFICE: 1929

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REPORT OF THE DIRECTOR OF THE EXTENSION SERVICE

UNITED STATES DEPARTMENT OF AGRICULTURE,
EXTENSION SERVICE,
Washington, D. C., September 24, 1929.

SIR: I have the honor to present herewith the report of the Extension Service for the fiscal year ended June 30, 1929.

Respectfully,

C. W. WARBURTON,
Director.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

PERSONNEL

The personnel of the Extension Service in Washington on June 30, 1929, consisted of 186 persons, of whom 7 were employed in the office of the director, 128 in the office of cooperative extension work, 27 in the office of exhibits, and 24 in the office of motion pictures. The field force on the same date consisted of 4,604 persons, of whom 4,588 were cooperatively employed by the department and the States in extension activities. The 16 field workers not cooperatively employed included 3 persons employed by the office of demonstrations on reclamation projects, 4 full-time employees of the office of cooperative extension work, and 9 employees of the office of exhibits. In addition to the persons employed cooperatively by the department and the States, more than 1,100 were engaged in extension work in the States who are not under appointment from the department.

FUNDS ADMINISTERED

The direct Federal appropriation for the Extension Service during the fiscal year was $2,012,480, of which $1,462,640 was for farmers' cooperative demonstration work and motion pictures, $11,540 for general administrative expenses, $375,000 for the employment of extension agents in flooded areas, $103,300 for exhibits, and $60,000 for farm-forestry extension. In addition, Federal appropriations amounting to $6,182,935 were allotted to the States and the Territory of Hawaii for extension work under the terms of the Smith-Lever and supplementary acts, and $980,000 under the terms of the Capper-Ketcham Act. The States, counties, and other agencies contributed $13,939,837 for cooperative extension work. The total of all of these items to be expended for motion pictures, exhibits, demonstrations on reclamation projects, and cooperative extension work with the State agricultural colleges was $23,115,252.

COOPERATIVE EXTENSION WORK

PERSONNEL

The office of cooperative extension work continued under the direction of C. B. Smith, chief, and J. A. Evans, assistant chief. On June 30, 1929, the Washington staff of the office comprised 9 administrative and supervisory officers, 13 organization field agents, 15 subject-matter field agents, and a clerical force of 91.

Alfred C. True, formerly director of the States Relations Service and since 1923 consulting specialist on States relations work, died April 23, 1929. During the earlier years of the development of extension work Doctor True played an important part in formulating policies and developing agricultural education and research. Since his retirement from active administrative duties in 1923, he had been engaged in the preparation of histories of agricultural extension, education, and research. His history of agricultural

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extension was published during the year, and that of agricultural education was in process of printing. At the time of his death the history of agricultural research was far enough advanced so that it can be finished by others along the lines designed by him. His long and useful service in the department in the interest of agricultural progress was, therefore, fittingly completed.

R. G. Foster, field agent in club organization for the Eastern States, continued on furlough for advanced study at Cornell University until June 1, 1929. W. A. Lloyd, in charge of extension work in the Western States, was granted a year's furlough to organize and direct the extension service in the Territory of Hawaii, which had been granted funds sufficient to carry out the terms of the Smith-Lever Act. He was appointed dean and director of the Hawaiian extension service on October 25, 1928, when the work was begun in cooperation with the University of Hawaii. Since that date C. B. Smith, chief, has been handling the work in the Western States in addition to his other duties. Mary A. Rokahr was appointed as extension agent in home management on February 1, 1929. The position of extension forester in the Washington office was vacant during the year. Roud McCann resigned as director of extension work in Colorado on January 15, 1929, and President Charles A. Lory acted as director. G. I. Christie, who had been director of extension work in Indiana for the last 13 years, resigned in August, 1928, and was succeeded by J. H. Skinner. W. R. Perkins, director of extension work in Louisiana, resigned June 30, 1928, and was succeeded by W. B. Mercier.

The entire State field staff on June 30, 1929, numbered 5,691 persons, an increase of 530 during the year. Of this number, 4,170 were located in the counties, of whom 2,452 were in county agent work, 1,167 in home demonstration work, 252 in boys' and girls' club work, and 299 in negro extension work. The county extension agents were supplemented in their work by 825 full-time and 212 part-time subject-matter specialists located at the State agricultural colleges. There were 409 supervisors and assistant supervisors, and 75 administrative officers and immediate assistants. During the year there was an increase in the field staff of 495 county workers, 2 administrative and supervisory workers, and 33 subject-matter specialists. Of the 495 new county workers added, 77 were county agricultural agents and 57 were assistants; 12 were negro county agents; 201 were county home demonstration agents, and 25 were assistants; 17 were negro county home demonstration agents; 95 were county boys' and girls' club agents, and 11 were assistants. Of the total number of field workers, 4,588 were cooperative employees of the department, practically all engaged either in county extension work, supervision of county work, farm-management demonstrations, or farm-forestry extension.

FUNDS

The total funds available for cooperative extension work from all sources during the fiscal year were approximately $22,918,200, an increase of nearly $2,000,000 over the previous year. Approximately $1,500,000 of this increase was in Federal funds and $500,000 in State and county funds. The Capper-Ketcham Act of May 22 1928, made $980,000 of Federal funds available July 1, 1928, and Congress appropriated an additional $280,000 of Federal supplementary funds. The remainder of the increase in Federal funds was for the employment of agents in counties in the flood-devastated areas. Of the total funds, 39 per cent, or $8,978,363, was contributed by the Federal Government, exclusive of the privilege of using penalty envelopes; and 28 per cent, or $6,405,825, was from State appropriations to the agricultural colleges and other State agencies. The remaining 33 per cent, or $7,534,012, came from county appropriations for extension work and from contributions by local organizations and individuals. About 94.5 per cent of all funds used for cooperative extension work in 1929 came from public sources.

Of the Federal funds, $6.182,935 was made available by the Smith-Lever Act and an appropriation supplementary thereto, $980,000 by the Capper-Ketcham Act, and $1,815,428 from direct appropriations to the department. Of the total funds, $14,554,775 (63.5 per cent) was allotted for extension agents in the counties; $1,186,380 (5.2 per cent) was allotted to the State agricultural colleges for administration; $2.345.610 (10.2 per cent) for supervision of county extension workers; and $4,328,660 (18.9 per cent) for the employment of subject-matter specialists. About $107,975 (0.5 per cent) was unexpended at the close of the year. The remaining 1.7 per cent,

or $394,800, was for activities of the Federal Extension Service at Washington, D. C.

The Territory of Alaska was extended the benefits of the Smith-Lever Act by an act approved February 23, 1929. However, no Federal funds were appropriated for this purpose during the fiscal year.

PROGRESS

GENERAL RESULTS [1]

In helping farm people to obtain a larger farm income and to make their home life more comfortable and attractive, extension workers supervised a total of 851,526 result demonstrations that were carried on by farmers and farm women as practical and inspiring lessons to their neighbors. This was an increase of more than 79,000 over the previous year. Boys' and girls' 4–H club members completed 882,795 demonstrations in better practices, as compared with 776,029 completed in 1927.

These demonstrations, supplemented by the press, bulletins, extension meetings, tours, campaigns, and other effective methods of increasing the sphere of influence of the demonstration, resulted in a total of 4,662,097 instances in which farmers, farm women, or 4–H club members adopted and put into use the practices taught by extension workers. The extent to which the practices advocated were accepted increased in most subject-matter lines of work, the largest increase being in nutrition. Slight decreases were evident in the work with rodents and insects, cereals, legumes, and forage crops, rural engineering, and home management. Considering the results obtained nationally, the extension program has become fairly well stabilized, decreased emphasis on a particular subject in one section of the country being offset by an increase in emphasis in another section.

Valuable assistance was given the extension workers by 237,817 volunteer local leaders who gave their time and effort in the formulation of extension programs, training club members, conducting demonstrations, and in other ways helping to make extension efforts more productive. Of these volunteer local leaders, 179,559 worked with adult farmers and home makers, and 58,258 worked with juniors. These local leaders were trained by extension workers, who held 42,902 meetings for this purpose, at which the attendance was 411,744.

ADULT ACTIVITIES

The greater percentage of time of county agricultural agents and specialists was devoted to helping farmers in crop production, although dairying, poultry, animal husbandry, and horticulture were also given considerable attention. In helping farmers to formulate plans for future improvement of production and marketing, county agricultural agents cooperated with them in building programs of work for 33,385 communities. County agricultural agents made more than 1,435,000 visits to about 742,000 farms. They prepared 275,800 news articles for the press; held 366,200 field meetings; distributed almost 4,000,000 bulletins; and advised farmers who made more than 3.000.000 calls at the agents' offices.

In activities relating to the farm home, the greater percentage of time was given to aiding farm women in the making, care, and cleaning of their clothing. Community activities, foods, and nutrition were next in importance. In helping the farm woman to put into practice the better home-making methods recommended by the extension service, home demonstration agents were assisted by 49,624 local leaders. In cooperation with local farm women, home demonstration agents prepared extension programs for 20,416 communities. They made about 288,000 visits to 165,000 farm homes, received 459.000 visits at the office, and prepared 84,800 news items for the press.

BOYS' AND GIRLS' 4–H CLUB ACTIVITIES

The enrollment of different boys and girls in 4–H club work has increased steadily during the last five years, the increase per year having averaged approximately 41,000 boys and girls. The enrollment in 1928 was 663,940, as compared with 619,712 in 1927. They were organized into 46,670 groups, known as 4–H clubs. That agents are giving more of their attention to junior activities is indicated by the fact that in 1928 an average of 180 club members were enrolled in 4–H club work per agent, as compared with 149 in 1924. Of the total number enrolled in 1928, 67.4 per cent completed their work. They conducted 882,795 demonstrations in better practices, an increase of 106,700 over the previous year. Assisting the cooperative ex-

[1] All extension field reports are submitted for the calendar year; hence, figures in this report on cooperative extension work, except where the fiscal year is indicated, are for the year ended Dec. 31, 1928.

tension agents in training these club members were nearly 60,000 volunteer local leaders, many of whom were former club members. Agents trained approximately 8,000 junior livestock-judging teams and 18,600 junior demonstration teams, who gave public demonstrations of the better methods they had learned in their club activities.

Some of the results obtained by club members during the year were the cultivation of 37,000 acres of corn, 21,500 acres of cotton, 5,800 acres of potatoes, 5,500 acres of peanuts, 2,000 acres of wheat, 1,540 acres of soybeans, and 7,760 acres of home gardens; 68,500 hogs, 35,000 dairy animals, 24,800 sheep, and 1,473,600 standard-bred fowls were raised; 3,356,000 quarts of fruits, jellies, and vegetables were canned, and 528,700 articles of clothing were made.

In June the third annual 7-day encampment of 4–H club members was held in Washington, D. C. Forty States and the Territory of Hawaii sent 150 delegates who were selected according to their 4–H achievements. The camp gave these youthful farmers and home makers an opportunity of becoming better acquainted with the work and facilities of the department, enabled them to learn how the Federal Government operates, and allowed them to discuss 4–H matters of mutual interest with delegates from other agricultural regions.

EMERGENCY ACTIVITIES

Vigorous relief measures to aid farm families after the tropical hurricanes that swept Florida and contiguous States in August and September, 1928, and the floods that inundated Alabama, Georgia, and Florida in March, 1929, were undertaken by the extension services of these States. Following the hurricane, Florida extension agents gave valiant aid to stricken farmers. They advised farmers in the selection of seed, planting, and cultural practices with reference to those crops that would mature quickly and return an income at the earliest possible moment. They aided in organizing community and county loan committees in their counties to pass on all applications for loans from the Federal Government and in many ways helped farmers to resume their routine-crop operations.

In Alabama, following a personal survey of the flooded area made by Director L. N. Duncan, extension workers of the State were concentrated in Coffee and Geneva Counties, where the March floods caused the greatest devastation. Here they assisted farmers to resume their farming practices and rehabilitate their homes. Cooperating with the American Red Cross, the Alabama Extension Service gathered approximately $100,000 and 15 carloads of food, clothing, and other supplies to meet the immediate needs of the refugees. Shipments of fertilizers to the flooded areas were arranged through the Alabama Farm Bureau Federation. Typical of the cooperation given the Alabama Extension Service was the arrangement according to which hatcheries and feed houses supplied several thousand day-old chicks and mash to feed them. Each farm family was supplied with 100 baby chicks and 100 pounds of feed as a start toward replacing the home poultry flock. Home demonstration agents gave demonstrations in refitting for use furniture damaged by the flood and aided families to put their homes in a livable condition. The Alabama Extension Service also arranged to bear the entire cost of maintaining county extension agents in the two counties until June 30, thus releasing a considerable amount to the county for use in repairing roads and other reconstruction.

EXTENSION STUDIES

FIELD STUDIES

Cooperative studies of the effectiveness of extension and the relative efficiency and costs of the various methods used were continued during the year under the direction of M. C. Wilson, who was in charge of this unit.

New extension studies were made during the year in Illinois, Kansas, and Nebraska. As studies had been previously made in Illinois and Kansas, only one new State was added to the list of States cooperating with this office in organized studies of extension. Studies involving farm and home surveys have now been made in 18 States. In addition 4 others have furnished extension cost data, making a total of 22 States in which some extension study has been made.

A total of 1,388 farm, home, and leadership records were obtained during the year, making nearly 15,000 records of various kinds that are available for analysis and study. Fifty-eight additional members of the State extension services and two members of the staff of this office were afforded the opportunity of becoming familiar with the survey method of studying the or-

ganization and conduct of extension work.

The Illinois study, data for which were collected during July, 1928, is a duplication of a similar study made in that State in 1926. The second study was made at the request of Dean H. W. Mumford, who desired to have more members of his staff have the beneficial experience of talking with farming people in an average cross section of the State regarding the use they are making of the extension service.

The Kansas study is concerned with analyzing the activities of volunteer local leaders in order to determine more accurately their part in extension teaching. Since Nebraska has not made a general study of the effectiveness of extension work in reaching rural people, the study in that State involved a general farm and home survey of the use made of extension information, and in addition local leadership records were obtained, as in Kansas. The data from Kansas and Nebraska were collected in April and May, 1929, and are being prepared for publication.

The studies in Michigan, Rhode Island, and Illinois corroborate the data obtained earlier in Kansas as to the effect of age of farmers and farm women upon adoption of improved farm and home practices. From the studies in these four States it is evident that age alone is no barrier to acceptance by farmers and farm women of the new or better practices taught by the extension service. Fully as high a proportion of the farmers 36 to 55 years of age as of the farmers 35 years of age and less changed practices through extension influence. The same tendency is true of farm women, although the volume of home economics extension work conducted is somewhat less than that of agricultural work. Desire to learn is apparently more important than age.

A large contribution to extension knowledge during the year resulted from the completion of the study of the relative costs of extension means and agencies started last year with the assistance of Director H. J. Baker, of New Jersey. For the first time information was made available regarding the proportion of extension funds expended upon the various teaching means and agencies. By far the heaviest users of extension time and money are the result demonstration, the method demonstration, farm and home visits, and general meetings. These four means account for the expenditure of more than 56 per cent of extension moneys. Relating costs to relative effectiveness of the various means and agencies gives some most valuable information as to the relative efficiency of individual means and agencies. Those means that exert greatest influence upon adoption of practices are not in all cases the heaviest consumers of funds and effort. The converse is equally true.

Assuming that it cost $4.74 [2] on the average to influence the adoption of a practice, it is possible to express the efficiency of extension means and agencies in terms of dollar-cost per practice influenced. News service is apparently the cheapest means of extending information, with circular letters, general meetings, office calls, bulletins, and farm and home visits above the average in low cost of practice influenced. Result demonstrations were twice as expensive as the average in bringing about changes in practices.

Reports on the effectiveness of extension work in selected areas of Illinois, Rhode Island, Michigan, Georgia, and Arkansas were published in mimeographed form during the year. The reports regarding Georgia and Arkansas covered negro extension work only. A mimeographed circular was also issued on the effectiveness of home-economics extension in reaching farm women and one previously issued containing club data from extension studies was revised and amplified. Two technical bulletins were printed: No. 106, Extension Methods and Their Relative Effectiveness, and No. 125, Relative Costs of Extension Methods Which Influence Changes in Farm and Home Practices.

Data from extension studies were presented during the year to annual conferences of State and county extension workers in Arkansas, Kansas, Michigan, Rhode Island, and Pennsylvania; also to the Central States' conference of home-economics extension workers held at La Fayette, Ind. Results of the cost study were presented to the annual meetings of the Land-Grant College Association by Director Baker, who also presented these data to annual conferences of extension workers in New Jersey, Ohio, New York, and Massachusetts. At the conferences during the year there was a tendency to increase the amount of time devoted to extension

[2] Obtained by dividing the extension budgets for 1925, 1926, and 1927 by the total number of practices reported adopted during those three years due to extension effort.

research data. For example, at the Kansas conference a series of four lectures was given. There was increasing evidence that readjustments were being made in methods of conducting extension work as a result of the accumulation of research information.

SUMMARY AND DIGEST OF REPORTS

The statistical summary of extension work for 1928 contains information from the reports of 3,682 county extension workers who were assisted by the equivalent of 910 full-time subject-matter specialists. Two more of the States assumed responsibility for tabulating county reports, leaving but six States for which that work was performed by this office. The reports were tabulated, indexed, and summarized. A statistical summary of the results obtained by extension workers during the year was prepared and mimeographed as Extension Service Circular 106. Digests of narrative reports received from State and county extension workers and subject-matter specialists in 1927 were prepared and distributed during the year. These covered the subjects of home industries, extension-program development, and farm buildings and farm machinery.

FARMERS' INSTITUTES

Thirteen States reported farmers' institutes conducted as a state-wide activity during the year ended June 30, 1928. This is two more States than reported farmers' institutes the preceding year. A total of 2,545 institutes extending over a period of 3,820 days and 9,026 sessions with an attendance of 1,353,843 persons were conducted. The instruction at these institutes was given by 759 persons, of whom 236 were members of the extension services, 74 were from experiment stations, 28 from State departments of agriculture, and 421 from outside sources.

Information regarding extension activities in foreign countries was compiled throughout the year. Reports were mimeographed and issued covering extension work in Canada, Paraguay, Uruguay, England, Wales, Scotland, Denmark, Norway, Sweden, Finland, Germany, Italy, India, South Africa, and New Zealand.

VISUAL INSTRUCTION AND PUBLICATIONS

The dissemination of extension information through the press, publications, radio, posters, lantern slides, photographs, and charts, and instruction in methods of visualization continued under the direction of Reuben Brigham. The popularity of visual material, radio, and extension house organs among extension workers increased materially during the year.

PUBLICATIONS

Nine new publications were written by various members of the staff of the office of cooperative extension work, printed, and released during the year, as follows:

Report of Director of Extension Work, 1928; Miscellaneous Publication 15, History of Agricultural Extension Work in the United States, 1785–1923; Circular 57, The Rural Church and Cooperative Extension Work; Miscellaneous Publication 35, Cotton or Weevils; Circular 58, Planning and Conducting Extension Campaigns; Leaflet 33, Combination Cleaning and Treating of Seed Wheat; Circular 43, Lessons on Cotton for Elementary Schools; Cooperative Extension Work, 1926; Technical Bulletin 106, Extension Methods and their Relative Effectiveness.

The following publications were in press at the end of the year:

Miscellaneous Publication 36, History of Agricultural Education in the United States, 1785–1925; Circular 43, Home Demonstration Work under the Smith-Lever Act; Miscellaneous Publication 52, How to Find Economic Facts and Apply Them as a Basis for Extension Programs in Home Economics, Dairying, and Forestry; Technical Bulletin 125, Relative Costs of Extension Methods which Influence Changes in Farm and Home Practices; and 31 illustrated educational charts.

The following popular publications were reprinted to supply the demand for copies from extension workers:

Leaflet 33, Combination Cleaning and Treating of Seed Wheat; Farmers' Bulletin 927, Farm Home Conveniences (revised).

The following 27 contributions were made by the staff to the series of mimeographed extension service circulars:

No. 83, Some extension administrative problems; No. 84, Foreign agricultural extension activities; No. 85, Home industries; No. 86, The public attitude toward extension work; No. 87, Interpretation of the Smith-Lever Act; No. 88, Extension program development—1927; No. 89, Effectiveness of extension in influencing rural people; No. 90, Foreign agricultural extension activities; No. 91, Farm buildings and farm machinery; No. 92, The relationship of the extension service to farmers' cooperative associations; No. 93, Factors which affect extension morale; No. 94, Classified list of articles in the United States Department of Agriculture Yearbook for 1927; No. 95, Film slides in the teaching of agriculture; No. 96, Foreign agricultural extension activities; No. 97, Extension results as influenced by various factors; No. 98, How to find and apply economic material as a background for a

farm and home program; No. 99, The house we build; No. 100, Foreign agricultural extension activities; No. 101, The effectiveness of home economics extension work in reaching farm women; No. 102, Farmers' institutes; No. 103, Extension service circulars of the United States Department of Agriculture—Numbers 1 to 100 inclusive. Issued from March, 1926, to April 1929; No. 104, Measuring the progress of extension work; No. 105, The immediate future of extension work; No. 106, Statistical results of cooperative extension work, 1928; No. 107, Club data from extension studies; No. 108, The farm youth and their economic background; No. 109, The 4–H club situation.

INFORMATION

In response to requests for dissemination of information regarding home demonstration undertakings which would be helpful to those carrying on home demonstration work, a new series of mimeographed releases for distribution to home demonstration workers was begun under the title "Here and There with the Home Demonstration Worker." The first issue appeared May 8, 1929, and three had been prepared and mailed by the end of the fiscal year.

Twelve numbers were issued of the Boys' and Girls' 4–H Club Leader, a house organ devoted to developments in 4–H club work, and were sent to all extension workers. These numbers contained an average of 59 articles and an average representation of 32 States per issue.

Informational news relating to cooperative extension activities prepared and disseminated through the department press service during the year included 202 items. Fifteen signed articles on particular phases of extension work were prepared by members of the staff of the office of cooperative extension work on request by editors of various magazines and farm journals and were transmitted through the department press service. Informational photographs illustrating phases of extension work were selected to meet specific needs expressed by editors of newspapers and agricultural and general publications and were sent through the press service with statements regarding the work illustrated. A total of 1,529 photographs was used for this purpose.

Photographs and information relating to extension work were furnished the department Press Service also for incorporation in 33 articles in a monthly contribution to the household editors of 10 newspaper services and farm journals, for which 320 photographs of extension activities were used.

Information regarding the club achievements of each of the delegates to the third national 4–H club camp was obtained in advance and statements prepared for press use. Each State represented at the camp was given opportunity to furnish a list of newspapers interested in receiving news of the camp, and from the response a mailing list including 279 newspapers was made up to receive the camp press releases. During the week of the camp a daily press release was prepared for five of the daily newspapers published in Washington and for correspondents of newspapers published in the various States. During the week 21 special stories were telephoned to reporters and correspondents, 22 stories were furnished to representatives of various farm journals and magazines visiting the camp, and 405 prints of photographs of camp activities were released to extension editors of the States having delegates in camp or to newspapers which they designated, or to representatives of farm journals and papers. A daily press release covering camp activities was prepared and sent to the State newspapers which had been listed; arrangements were made through the department press service for a news sound-reproducing and motion-picture firm to cover one of the camp events; assistance was given in the preparation of material used in three radio programs which included camp features; and a daily camp newspaper was issued, which contained stories of camp events prepared by 53 of the delegates to the camp.

VISUAL INSTRUCTION

Talks on photography and the preparation and use of visual material as applied to the extension field, followed by discussion and practical demonstrations, were given at conferences of extension workers in 10 States, as follows: Arkansas, Georgia, Louisiana, Michigan, New Jersey, New Mexico, Ohio, Rhode Island, Texas, and Virginia.

PHOTOGRAPHIC AND ART SERVICE

In cooperation with State extension divisions, several carefully planned series of field photographs illustrating extension work were obtained for use in publications, information service, exhibits, and posters, and for distribution in lantern-slide form. In this work five States were included—Maryland, New York, North Carolina, Penn-

sylvania, and Virginia. A total of 2,251 new field photographs were taken on these trips.

The photographic reference file of the office includes illustrations on a wide variety of agricultural and home-economics subjects in constant use by department and field employees and cooperators. This file includes 37,482 photographs, 3,519 new illustrations having been added during the year.

A total of 40,282 negatives, prints, slides, enlargements, charts, posters, and drawings was requested and prepared for use in extension work. Of these items the Office of Information prepared 3,519 negatives, 28,047 prints, 6,092 slides, 455 enlargements, and 1,388 miscellaneous items inculding blue prints, and the section of visual instruction and editorial work prepared 184 charts, 98 posters, and 499 drawings. The remaining orders for 84 negatives, 4,691 prints, 1,644 slides, and 299 bromide enlargements were filled by commercial concerns holding the department's contract.

Special assistance was given State extension divisions in the designing and preparation of posters, bulletin covers, cartoons, and drawings for illustrating house organs, newspaper advertisements, charts, and simple exhibits. A series of six posters on poultry production and marketing was prepared in cooperation with the Georgia Extension Service for use in Georgia. The art work consisted of the coloring of 6,116 lantern slides, 39 bromide enlargements, and 122 photographic prints; the preparation of 645 sketches and designs; the lettering of 5,094 cards, placards, and signs; and the preparation of 98 posters and 200 charts and graphs.

LANTERN SLIDES

Six new series of lantern slides were added to the collection during the year, making a total of 195 series now available for loan. These new series were on the following subjects:

Series 238, Come into the kitchen; 240, Horseshoeing; 244, Soil erosion—a national menace; 247, The Japanese beetle; 248, The codling moth; 249, The structure of insects.

The following seven series were revised:

Series 17, Farm poultry raising; 36, The peanut; 44, Breeds of swine; 52, Swine management; 54, Diseases and sanitation; 113, Growing small fruit; 242, Seeing Washington.

Twenty-four series were placed on film strips during the year, as follows:

Series 17, Farm poultry raising; 44, Breeds of swine; 52, Swine management; 113, Growing small fruits; 143, Standard baskets for fruits and vegetables; 173, Marketing feeds through dairy cattle; 175, Production of clean milk; 180, How insects attack garden vegetables and methods of control; 194, Roundworms and swine sanitation; 211, Cooperative marketing of cotton; 226, Selection and care of seed corn; 227, Cultivating the corn crop; 234, Chicken lice, mites, and other external parasites; 239, Care of the laying flock; 240, Farm horseshoeing; 242, Seeing Washington; 244, Soil erosion—a national menace; 247, The Japanese beetle; 248, The codling moth; and five special series including Home demonstration work, parts 1 to 4, inclusive, and Marketing our work. Series 178, Better cotton on fewer acres, was revised.

A total of 1,147 shipments of lantern-slide series on glass and 165 of film strips were made to extension workers, teachers, and cooperating agencies requesting the loan of lantern slides. Extension workers and others in 46 States borrowed glass-slide series, and 34 States borrowed film strips.

The purchase of positive prints of department film strips from the concern holding the department's contract increased from 968 in 1927–28 to 2,279 in 1928–29, or more than double the number, indicating a considerable increase in interest in film strips. All but four States purchased copies. Two States were assisted in the preparation of film-strip series from their own photographs for local use.

RADIO

Opportunity to release information to the general public regarding extension work with farm boys and girls was offered through the cooperation of radio broadcasting stations working with the department radio service. For this purpose material was furnished to the radio service for 30 weekly programs, known as the Four–H Club Crier, beginning with that released October 1, 1928, and ending with the release of April 22, 1929. Special effort was made to give adequate representation of the national extent of 4–H club work, and it was possible, through the cooperation of the State extension services, to broadcast during the 30 weeks a total of 246 stories of club news and accounts of club accomplishment in 46 States and the Territory of Hawaii. Sixty-one broadcasting stations used the Club Crier. Thirteen radio talks relating to developments in extension work were also prepared and given by members of the office of cooperative extension work as contributions to

the department's first series of noon-hour radio programs broadcasted over an extensive network of stations.

By means of a national hook-up of 31 broadcasting stations arranged by the department radio service and the National Broadcasting Co., and associated stations, the 700,000 members of 4–H clubs throughout the country had the opportunity to participate in one of the evening programs of the third national club camp at Washington, D. C. The program was broadcast on June 22, the fourth day of the camp, from the auditorium of the National Press Club. Two club members, two State extension workers, the chief of the office of cooperative extension work, and Mrs. Herbert Hoover spoke during the program at which the Director of Extension Work presided.

AGRICULTURAL INSTRUCTION

The section of agricultural instruction, under the direction of E. H. Shinn, continued as in the previous year, to make studies of activities, problems, and methods involved in conducting extension work in agriculture and home economics. The method of approach in these investigations is concerned with the educational aspect of extension work and the method of procedure used, rather than with measuring the results that extension workers are accomplishing. These investigations entail intricate study and detailed analysis of the content and method in the particular phases of the work under consideration.

As a form of instruction, extension work in agriculture and home economics is a comparatively new educational procedure. The content of instruction and the teaching methods used represent a new way of approach to the numerous problems affecting the welfare of the farm and the farm home. Obviously, many of these problems are more serious and complex than others. In formulating a program of instruction, the extension worker has had little guidance from educational sources because of the lack of available information that could be used effectively in extension teaching. Notwithstanding this fact, rapid progress has been made.

THE YEAR'S STUDIES

Problems that are directly concerned with extension education were studied and analyzed during the year. In these investigations consultations were held with members of other sections of the office and with extension workers and other educators in various States. Helpful criticisms and suggestions were received from these sources.

A study entitled "An analysis of the managerial responsibilities of the farm home maker" was completed during the year and made available as a mimeographed circular. Favorable comments were received from a number of State home demonstration leaders and home-management specialists in extension work as to the possible value of the content of this study in home-management extension work. The study represents a detailed analysis of the managerial aspects of home making on the farm and is concerned chiefly with those functions in home management that involve making choices when optional situations arise. In connection with the study, personal visits were made to representative States in different sections to confer with State leaders of home-economics extension work and with home-management specialists and others. The plan and content of the study were thoroughly discussed with them, and criticism and suggestions were solicited. The manuscript was circularized among the home-economics extension staff of the office, and some helpful suggestions were received. Personal interviews were also held with leading farm women in several States to obtain their views as to the reliability of the content of the study, as well as its practical value to farm home makers. Requests were received from workers in several States who desired the services of the author of the study in formulating home-management projects.

A study undertaken and completed during the year by a member of the staff related to adult local leadership in extension work, in connection with which field trips were made to Georgia, Kansas, and Nebraska, and to the annual meeting of county agents of New York at Cornell University. Inasmuch as local leadership constitutes an important element in the success of a county-extension program, the data obtained in this study should have value to extension workers.

Considerable progress was made on the study of the educational value of 4–H club work, but it is not yet ready for publication. A vast amount of data has been received from State leaders of 4–H club work, a number of county and home demonstration agents, parents of 4–H club members, and sev-

eral hundred boys and girls who have participated in club activities. The first section of this study is nearing completion. The author of this study visited Camp Vail, at Springfield, Mass.; the National Club Congress, at Chicago; the National Dairy Show, at Memphis; and the annual conventions of 4–H clubs in several States. At each of these places interviews were held with State leaders of club work and with the boys and girls themselves during which questions were asked regarding club activities and the methods used in conducting the club programs. From these contacts some very helpful suggestions were gathered.

In addition to making studies of extension education, the service to agricultural teachers was continued. This service consisted for the most part in distributing lantern slides, lists of sources of illustrative material, lists of publications of the department, educational charts, soil samples, and other kinds of material.

Thirty-one additional educational charts were completed and submitted for printing during the year. These were in press at the end of the year and when printed will make a total of 84 charts available for purchase from the Government Printing Office. The new illustrated charts cover such subjects as weaves and wearing qualities of textiles, fitting blouses, furniture woods, cuts of pork and lamb, proper labeling of food, selection of citrus fruits and potatoes, storage of vegetables, foods valuable for different vitamines, and charts on nutrition. Three series of slides relating to home-economics work from the consumers' standpoint of milk, eggs, and meat were prepared. Members of the staff contributed two articles for the Yearbook of Agriculture, 1928.

In connection with the study of special courses for preparation of agricultural and home-economics extension agents, made by members of the staff in 1927, some follow-up work was done in three States in the form of conferences with directors of extension, State leaders of county agents, and with heads of teacher-training divisions in land-grant colleges in order to formulate a program of training for prospective extension workers. In one of these States a definite course of instruction was organized and put into operation during the past school year. Some form of special training for extension workers is now in operation in about one-third of the agricultural colleges. There is a growing sentiment in a number of States in favor of better facilities at the agricultural colleges for training those who contemplate entering extension work.

A member of the staff continued to act as secretary of the committee on instruction in agriculture, home economics, and mechanic arts of the Association of Land-Grant Colleges and Universities. Since the death of A. C. True, the secretary has been asked by the executive committee of the association to act as chairman of the committee during the remainder of the year.

SUBJECT-MATTER FIELD AGENTS

The activities of subject-matter field agents remained under the direction of A. B. Graham. The staff was increased by the addition of Mary A. Rokahr, formerly State leader of home demonstration work in Wyoming, as field agent in home management.

More attention was given during the year to the use of a greater variety of means and agencies for the purpose of reaching more people. Therefore, the methods of conducting extension work from the standpoint of needs of the people were more fully developed than in previous years. At every regional conference methods of teaching adults had a part in every program. Practically every State conference had a place for extension methods of teaching. Boys' and girls' club work made an increased claim on the efforts of subject-matter field agents.

AGRONOMY

Two lines of work that stood out prominently during the year were the improvement in quality of crops grown primarily for direct marketing and the production of better feed crops from home sources for dairy cattle, general livestock, and hog production.

Thirty-nine States conducted definite work in seed improvement. Of these States 29 worked in cooperation with organized seed-improvement associations. The foundation seed, developed by the experiment stations was multiplied under careful supervision and made available for the use of farmers primarily in their own community and county. Corn, wheat, and other small grains and potatoes were the principal crops handled in these seed-improvement associations.

Alfalfa improvement was carried on in Idaho, Michigan, Montana, Nebraska, and Utah and clover improvement in Colorado, Idaho, and Tennessee.

Another phase of the seed-improvement program was the placing of im-

proved seeds in sections of the States where they were best adapted. Feed-production centered very largely around the growing of legumes and pasture improvement. Extension work in legumes was reported from 38 States. Demonstrations in the growing of alfalfa continued as the outstanding work in legumes. One of the most important features of the work with alfalfa was the certification of seed as to its source. It proved to be comparatively easy under the scheme which has been quite generally accepted by commercial interests to trace sources of alfalfa seed and thereby determine its adaptability.

Sweet clover was used principally for pastures and soil improvement in Illinois. The acreage has been increased from 48,000 in 1919 to 619,000 in 1927. Soybeans was the subject of extension work in 15 States. This crop has dropped out of the program very largely in such States as Michigan and Wisconsin but continues to be one of the principal legume crops in the Southern States, especially Alabama, Georgia, North Carolina, South Carolina, and Virginia. In the Southern States, where the lime requirement is so high, there is a serious handicap in the production of many of the legumes, but Lespedeza has proved superior in the South to other kinds of leguminous crops. In North Carolina it was found that 58 out of 78 county agents were doing some definite demonstration work in Lespedeza in 1928. One county reported the saving of 30,000 bushels of Lespedeza seed for sowing in 1929.

Pasture improvement was reported from 18 States in various sections of the country. In the Southern and Western States the improvement resulted largely from seeding with proper grass mixtures. In the Eastern States the work consisted of rebuilding old pastures principally by using commercial fertilizers and lime and, to some extent, reseeding. Weed control became an extension activity in 11 States. In at least 3 States the extension force had special workers on weed control. Five-acre and 10-acre corn contests were held in Indiana, Iowa, Ohio, and Nebraska.

In soil improvement the application of lime continued to be one of the outstanding phases in the Central, Eastern, and, to some extent the Southern States. This work was limited somewhat because of the lack of distributing agencies and, in some sections, of available sources of lime. Although marl beds have been developed, limestone rock still continued to be the principal source for agricultural purposes.

Assisting farmers to make lime surveys of their own farms was an interesting phase of the work in Illinois. This was done by training local leaders in various counties. Following this training the leaders returned to their communities, called together groups of farmers, and helped them in testing their fields for lime requirement. After a brief training the farmers themselves were able to make their own field tests fairly accurately.

Extension work on the use of high-analysis fertilizers has extended to 23 States, according to reports received. In a few States demonstrations of the home mixing of fertilizers have been held. Missouri continued to stand first in the percentage of high-analysis fertilizers used. The change from low-grade to high-grade fertilizer was very largely due to demonstration work and the campaigns carried on by the extension service. There was fine cooperation by the fertilizer manufacturers and selling agencies and by the experiment stations in putting out information as to the type of fertilizer to use and in recommending that all agencies cooperate in seeing that the high-analysis fertilizers were stocked and recommended by local dealers.

Extension work with green manures was reported from only eight States, but in many States work of this kind was done although not regularly reported. Most of the work with green manures was reported from the Southern States, where vetch and Lespedeza were used very largely. In a few of the Central States sweetclover, rye, and other green crops were used for the same purpose.

Alabama outstripped all States in the use of vetch seed. In 1927 the use of 790,649 pounds was reported, and in 1928 the report indicated that 1,127,096 pounds of seed was used for winter seeding of vetch. The campaign in this State was carefully planned, both for the State and the counties. Cooperation of the State farm bureau was secured in the purchasing of seed for the farmers. Several weeks before the campaign was started publicity was furnished to the local and State press. Special information was furnished to the agents and other interested people. Speakers were assigned to each county, and cooperation was secured from the leading farmers and Smith-Hughes teachers. Luncheon clubs and business organizations were told of the work.

The bankers, business and professional men were invited to assist. A number of tours were taken to farms where vetch had been used. In some counties every farmer who attended one of these tours planted vetch. Hundreds of meetings were held in schoolhouses, churches, country stores, courthouses, and in the field. Every day dispatches were telegraphed to the college of agriculture in order that the editor could put out special press articles. During a period of three weeks the attention of the entire State was centered on vetch.

Terracing, irrigation, and drainage demonstrations were held in several States, but terracing seems to have claimed the greater part of the attention in the South and Southwest.

During the year 60,135 demonstrations in soil improvement were carried out by farmers in cooperation with extension workers. Commercial fertilizer was used for the first time by 164,877 farmers; 47,153 farmers used lime or limestone; 47,148 took better care of their farm manure; 38,637 plowed under green-manure crops; and 49,515 adopted other practices designed to increase soil fertility. Altogether, there were 306,491 instances reported in which farmers accepted the better practices advised by extension workers. This was an increase of almost 27,000 over last year.

HORTICULTURE

In 44 States definite horticultural projects were conducted and in the remaining 4 States county agents advised farmers concerning the growing of fruits or vegetables. The raising of certified seed potatoes invited some interest in the formation of certified seed potato buying pools. This interest had a tendency to eliminate many varieties of potatoes used in southern potato-growing territories. In the New England States progress was made in the reworking of old trees to seven varieties of apples agreed upon by growers and extension horticulturists as the most practicable for commercial purposes.

Orchard cost accounting was carried on in a few States in cooperation with farm-management specialists. The amount of service work performed for individuals gradually declined. The number of demonstrations carried on with tree fruits was 12,980; with bush and small fruits, 1,758; and with grapes, 1,733. Agents taught 11,265 farmers to plant improved varieties of tree fruits; 18,685 adopted better pruning methods, and 26,005 sprayed their tree fruits or treated them in some other manner for disease or insect pests. A total of 70,766 different farmers accepted better practices in growing tree fruits; 11,637 in growing small fruits; and 10,350 in growing grapes.

A little less extension work was done in market gardening this year than last year. Reports indicated that 5,760 demonstrations were carried on with adults and that the activities of the agents caused 8,798 farmers to plant better stock or improved seed, and 7,538 to spray or otherwise treat for disease or insect pests. A total of 23,285 farmers adopted better practices in market gardening.

There continued to be a greater demand for information on landscape gardening and home beautification than it was possible to supply, although the number of demonstrations increased over last year. Adults, most of them women, carried on 30,236 demonstrations. Boys' and girls' club members completed 41,879 projects in home beautification. Altogether, 90,482 farm women and men put into practice the information on planting of shrubbery, shade trees, lawns, flowers, and other methods of improving the appearance of the farm home which they obtained from extension workers.

FORESTRY

One of the important features of forestry extension during the year was the thinning of young timber. This work was tried out in 25 States. Such factors as good markets and increasing timber values stimulated interest in thinning in the Southern and Eastern States. Forest management is closely related to timber thinning. This work involves the entire tract of farm woodlands. Extension agents assisted 5,476 farmers in this work.

Educational work in protecting the forests from fire was conducted in 31 States. Methods of preventing fires were demonstrated. Tours, campaigns, news stories, radio talks, posters, bulletins, and mimeographed material were utilized in disseminating information about woods burning.

Timber estimating was successfully demonstrated in most of the timbered States. Most of this work was in the New England States. Information given regarding markets was of great assistance to woodland owners. It has placed them more nearly on an equal bargaining basis with dealers than heretofore.

Forest plantings were established on 6,638 farms, and windbreaks were planted on 3,715 farms according to methods advocated by the extension agents. Windbreaks and shelter belts were given much attention in the mid-Western States; planting for fence posts was given much attention in the southern region; and plantings for producing saw timber and pulp wood received emphasis in the Northeastern States.

Satisfactory projects were developed among 4-H club boys and girls in 17 States. California, New Jersey, New York, and Wisconsin were leaders in this work. In one State the program of work covering a period of three years is as follows: First year, tree planting; second year, forestry appreciation; third year, wood-lot improvement. The 1928 4-H club enrollment contained the names of 4,031 children, of whom 2,719 completed their work, a considerable increase over the membership the previous year.

PLANT PATHOLOGY

The prevention of disease on practically all leading crops was an important activity during the year. In the corn-producing States the control of corn root rot was emphasized in the extension program. The introduction of disease-resistant and disease-free seed occupied much attention in vegetable-growing sections. In the Cotton Belt where wilt had gained a hold the advantages of disease-resistant types of cotton were presented. Cereal-seed treatment, certified seed-potato production, potato-seed treatment and spraying, and orchard-spray service continued to be the outstanding projects in a number of States.

The advantages of interstate cooperation have become increasingly apparent. An orchard-spray service has been worked out in the apple-growing sections of Maryland, Pennsylvania, Virginia, and West Virginia. The spraying programs published by these States and the recommendations sent out in other ways were similar in their main features. Another example of interstate cooperation was found in the spring-wheat area where seven States, the United States Department of Agriculture, and the Northwest Wheat Improvement Association cooperated in a campaign against stinking smut of wheat.

Improved or certified potato seed was planted by 36,265 farmers; 26,005 treated fruit trees for disease and insect pests; 43,203 sprayed for the protection of vegetables from disease and insects.

The use of printed leaflets, circular letters, demonstrations, agricultural trains, in addition to general oral discussions by extension-plant pathologists, were the methods through which these better practices were extended to the people.

RODENT CONTROL

Prairie dogs, ground squirrels, pocket gophers, rabbits, rats, porcupines, field and house mice, woodchucks, moles, and other rodents, and animals have become menacing pests to crops in certain sections of the country. In attempting to reduce the damage caused by these pests, extension workers in cooperation with the Bureau of Biological Survey of the department and State rodent-control specialists carried on campaigns to induce farmers to control destructive pests through poisoning. Farmers helped by carrying on 13,246 demonstrations under the supervision of extension agents. That the educational work was effective is indicated by the reports of 768 county agricultural agents who stated that 132,470 farmers had accepted the control practices recommended.

One of the accomplishments in cooperative ground-squirrel control during the year was the establishment of a central bait-mixing station in the Idaho district. Such a station assured the farmers good poison bait uniformly mixed and made available at all times adequate quantities at the lowest possible cost.

The control of prairie dogs was attempted in nine far Western States. In several of them extensive areas were cleared of prairie dogs, resulting in a material saving to the livestock and farm industries. One stockman in Arizona reported a saving of about $2,000 worth of grass. Operations for the control of jack rabbits were conducted in 13 States. One farmer estimates that there was a saving of $30,000 worth of cotton in his district from the poisoning of jack rabbits.

Cooperative campaigns for the control of pocket gophers have been carried on in 15 States. This work gave additional protection to large areas of forage and grain crops, fruit, and forest trees, as well as to irrigation water. More than 53,000 pounds of poison bait were used in the Wenatchee and Yakima districts in Washington alone to control field mice. This work was also carried on in California, Idaho, Oregon, South Dakota, Utah,

and also many Eastern States, such as Maryland, Maine, Pennsylvania, and Vermont.

The control of rats was undertaken in 16 States through organized campaigns in cities and country districts. Demonstrations were given of methods of destroying these pests. Notable among campaigns in the country districts was one organized in Texas covering 34 counties. In Ellis County, Tex., which has a population of less than 57,000 persons, 243,321 rats were destroyed in one month.

When woodchucks have their haunts immediately adjacent to farm lands they become a serious pest. In control measures undertaken in eight States poison baits and calcium cyanide as a fumigant were used to destroy them. Operations for the control of porcupines were carried on in six States to prevent damage to young trees.

ENTOMOLOGY AND BEE CULTURE

The outstanding extension entomological problems varied widely with their geographic distribution. In the South the cotton-boll weevil and the pink bollworm were among the most serious. In the Northeast and other apple-producing States the codling moth was given most consideration. In the Central States the control of the corn borer, the Hessian fly, and grasshoppers required the most attention. In the far Western States the army worm, crickets, leaf hoppers, and the alfalfa weevil were destructive insects the control of which was emphasized.

Many of the specialized fruit-growing areas have developed different types of spray service. Some use circular letters in advising farmers when to spray, some the telephone, and others a regularly organized force of persons to do spraying. In one State this work is conducted in cooperation with the United States Weather Bureau. Many of the methods for the control of the corn borer were based upon better farm practices and management. The greatest attention was given to areas where the corn borer has appeared for the first time. The spraying continued to be advocated and organized in many of the States where fruit growing and potato production are conducted as secondary farm enterprises.

The efforts of extension workers through 6,345 demonstrations and other supplementary methods of extending improved practices influenced the adoption of practical control methods for grasshoppers and other insect pests on 88,485 farms.

Beekeepers were somewhat hampered during the year by the poor flow of nectar. Alabama, Connecticut, Iowa, Louisiana, Michigan, New York, North Carolina, Ohio, Pennsylvania, and South Carolina developed their work in beekeeping along the lines of management, such as requeening, preparation for winter quarters, and disease prevention. In some States much attention was given to stimulating local markets through the help that nutrition specialists could give in the use of honey in cookery. Exhibits in store windows and at fairs were made to stimulate interest in the consumption of honey. In several States, especially in Connecticut, 4–H clubs were organized in beekeeping.

Extension agents reported that 1,514 adult demonstrations were conducted during the year, that 689 junior projects in beekeeping were completed, and that practically 6,000 farmers adopted the methods recommended by the agents.

ANIMAL HUSBANDRY

Continued attention was given to the making of State and local extension programs in animal husbandry. Careful and thorough studies of economic conditions, adaptability of enterprises, demands and supplies, competitive areas, and long-time trends in production were made by extension animal husbandmen to insure more successful results. Convincing demonstrations were responsible for most of the improvement shown in the adoption of better practices. The number of method and result demonstrations conducted during the year was substantially larger than in the previous years. In order to reach and influence more people simple practices in feeding and other phases of livestock extension work were given increasing attention.

A greater number of effective and satisfactory contacts were made with the representatives of commercial and semicommercial agencies in an effort to reach more people. Projects relating to range-livestock production were extended and improved by reason of the fact that new and useful results of research work were available.

County extension agents reported that 223,554 farms had adopted improved practices in livestock production during the year as compared with 198,516 in 1927. This increase applied in about equal degree to all classes of

farm animals. In the feeding of better-balanced rations for the first time the records show for 1928 that 35,623 farmers adopted better practices, an increase over the 34,110 who adopted them in 1927. The number of farmers assisted in obtaining purebred sires during the year was reported as 224,807. This is a slight increase over the figure for 1927. In junior 4–H club work the number of animals involved in 1928 was 117,958, as compared with 110,424 in 1927. This is an increase of over 52,000 in the past four years. An achievement worthy of special mention was the elimination in five counties of all bulls except registered purebreds. Three of these counties are in Kentucky, and one each in Virginia and North Carolina.

DAIRYING

Most of the States have long-time dairy programs leading to a definite goal. The work centered around four fundamental projects: Better sires, dairy-herd improvement, better feeding, and 4–H dairy-calf clubs. The better-sires project embraced such work as cooperative bull associations, scrub-bull eradication campaigns, and the safe-keeper bull-pen construction.

In the dairy-herd improvement methods were evolved for bringing the value of records of production to the attention of the dairymen. These methods included cooperative cow-testing associations or other methods of testing under the general direction of a county agent, cooperation with Smith-Hughes testing circles, and 500-pound cow clubs. Better feeding projects centered largely around feeding schools or meetings.

In the 4–H dairy-calf clubs the dairy specialists cooperated with the county club leaders in giving instruction in fitting, feeding, and judging of the calves. Many parents were reached through the dairy demonstrations made by children. Projects of a secondary nature, such as remodeling barns, the construction of new buildings, milk houses, and silos, were carried on.

Disease control, principally tuberculosis of dairy cattle and contagious abortion, were among the important projects in the more western States. In the Eastern States the problem of raising good heifer calves was acute, and an effort was made to solve it by advocating the use of calf rations from milk substitutes. In the Southern States cheese factories were aided. Creameries were assisted in their plant management.

California had the highest percentage of cows under test. Its goal for a long-time dairy program, maturing in 1930, is 265 pounds of butterfat per cow per year. The progress already made indicates that this goal will be attained easily. Indiana made great progress in a better-breeding program. One controlling factor was the use of safety bull pens. Campaigns for building such pens were carried on over the entire dairy area of the State. Illinois developed a plan by which the community leader assists in the supervision of the tester and his records. North Carolina has conducted better-sire campaigns for two years with outstanding results. During the year 862 purebred bulls were placed as the result of contests.

More than 29,800 demonstrations in dairying were carried on in the United States during the year, and 4–H club members completed about 29,500 dairy projects. Extension workers assisted 18,856 farmers to obtain purebred sires and 26,186 to obtain high-grade or purebred females. Herds were culled by 13,188 farmers with the advice of extension agents; better-balanced rations were fed by 68,151 farmers; and 260,650 farmers had their animals tested for tuberculosis. Better practices in dairying were adopted by 461,888 farmers, an increase of almost 33,000 over the previous year.

POULTRY

Three outstanding features in poultry extension during the year were the growing of healthy chicks, the maintenance of demonstration farm-flock records and the cooperation of commercial organizations. The rapid increase in the sales of baby chicks to raisers of poultry on farms increased the necessity for greater care in producing eggs for hatching purposes and in sanitary measures, both for housing and feeding young chicks. There are few outstanding poultry States that have not done any work in the "grow-healthy-chicks" campaign. The extension circular letters describing methods to farmers was of outstanding importance in this work. News items in local papers were also very helpful in disseminating poultry information.

The demonstration farm-flock record was emphasized in 28 States. The flock record may be divided into three types: (1) The calendar flock, in which the cooperator reports very sim-

ple statistics, such as egg production and mortality; (2) the demonstration flock, which is much more in detail and much more of an enterprise study; and (3) the cost-accounting record, carried on in cooperation with the farm-management extension specialists

The third important feature of poultry extension work was the increased tendency to use commercial organizations to assist in extension projects. This is particularly true in connection with poultry housing; contacts were made with associations of retail lumber dealers, retail hardware associations, and others. The turkey industry grew in many of the far Western, Southern, and Southwestern States. The difficulty in developing this work lay somewhat in the dearth of experimental results.

Extension workers taught 76,668 farm men and women to cull poultry, 80,560 to feed better-balanced rations, and 54,532 to control insect pests. On 30,418 farms poultry raisers were induced to obtain purebred cockerels, 22,339 were assisted in obtaining purebred females, and 5,574 were influenced to have their birds tested for tuberculosis. Demonstrations in poultry production were conducted by adults on 55,443 farms, and junior 4–H club members completed 56,900 demonstrations. More than 260,600 farms were reported as accepting and using the poultry practices recommended by extension workers.

RURAL ENGINEERING

The control of soil erosion continued to be the major agricultural engineering activity in all areas where soil erosion is serious. Many landowners reported that the increased crop yield the first year more than repaid the cost of the improvement. During 1928 terracing and soil-saving dams were constructed on 45,000 farms at a cost of from $5 to $10 per acre. Drainage systems were adopted by 5,500 farmers and irrigation systems by 2,100 farmers through extension influence.

Surplus war explosives were distributed largely by the extension force to clear cultivated land of large stumps and stones. Such demonstrations were conducted on 22,287 farms. No attempt was made to increase the area of cultivated land by clearing new land. The supply of pyrotol, the war explosive, which had been made available through the Bureau of Public Roads, became exhausted in April, 1928. After that date land clearing was accomplished by the use of commercial explosives.

Living conditions on the farms were improved through the installation of modern lighting, heating, water, and sewage-disposal systems. Plans furnished by extension workers were used by 4,900 farmers in installing sewage-disposal systems, by 3,600 farmers in installing water systems, by 590 farmers in installing heating systems, and by 3,600 farmers in installing lighting systems. With the aid of plans furnished by the extension agricultural engineers farmers remodeled 3,800 old dwellings and constructed 2,500 new ones. More than 18,600 farmers used better types of farm machinery, and 9,400 followed suggestions on the maintenance and repair of machinery as a result of the efforts of the extension agricultural engineers and county extension agents.

The improving of housing conditions for animals, crops, and equipment received much attention, as is indicated by the fact that 27,600 farm buildings other than dwellings were constructed or remodeled according to plans furnished by the extension engineering specialists. Cooperation with leaders in 4–H clubs led to the organizing of clubs in terracing, woodwork, machine shops, gas engines, and road making in 10 States. Some phase of modern farm engineering practice was adopted by 140,500 farmers throughout the country.

FARM MANAGEMENT

Extension workers gave considerable time during the year to teaching farmers the value of keeping simple and orderly records of their farm enterprises and of studying such records to ascertain the underlying reasons for profit or loss. The information gained from such studies enabled the farmer to determine his problems and plan readjustments in the size, volume, or organization of his enterprises that would result in a larger farm income. Facts concerning the existing agricultural situation and the outlook for farm commodities were disseminated. Extension workers also gave wide distribution to the data obtained from the records of farmers who were successful in solving the problems peculiar to a particular area or to certain conditions. The distribution of such timely economic data covering both short-time and long-time changes in production,

prices, consumption, and the movement of farm products helped farmers in planning the acreage of various crops and kinds of livestock in relation to the probable demand.

The successful improvement of lines of work, the efficient use of available labor, and the problem of reaching a larger number of people were pertinent factors in formulating farm-management extension programs during the year. An attempt was also made to present subject matter in simple and concrete terms and with such effectiveness that farmers would be influenced to adopt the better-management practices which the facts seemed to warrant. The methods of work dealing with principles and facts underlying the successful organization and operation of farms included demonstrations, meetings, schools, tours, leader training, exhibits, news articles, and the securing of local cooperators. Farm accounting has been in use for 15 years, and the experience gained during that time has been helpful in formulating successful methods of procedure.

Representatives of all State extension services were invited by the department to participate in the development of the national agricultural outlook for 1928. The extension services of 21 States were represented at the outlook conference. Following the national conference State agricultural outlooks were developed in 27 States. Data issued by the department forecasting the intentions of farmers to plant crops and breed livestock were also given wide distribution by extension workers. In 20 States a monthly publication was published, giving timely economic information.

In 1928, organized farm-management extension programs were conducted in 30 States, with one or more men devoting full time to the project. County agents in 1,489 counties reported that 73,800 farmers put into practice one or more of the better-farm-management methods taught by extension agents. Agents also reported that 23,900 farmers kept farm-account books, 17,500 were assisted in keeping cost-of-production records; 9,300 were advised concerning leases; 24,400 adopted the cropping, livestock, or complete farming systems recommended; and 8,900 made changes in their farm businesses upon the advice of the agent. Boys' and girls' club members also completed 8,360 farm-management extension projects.

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COOPERATIVE MARKETING

Reports received during the year indicate that there were definite trends toward a broader and clear understanding of cooperative marketing and purchasing; the standardization of grades, packing, and trade practices; placing cooperative marketing of agricultural products and purchasing of farm supplies upon a practical business basis; the development of stronger surplus funds during peak periods as a protection during unsatisfactory periods; and greater cooperation among cooperative associations resulting in a closer unification of commodity marketing.

Cooperative-marketing schools or conferences were carried on in several States in cooperation with the department and marketing and other leading farm organizations. These schools lasted from two to four days and were conducted along sound economic lines. Special group meetings were arranged for the discussion of particular marketing phases of special interest to any commodity group. In some States the facts brought out during these schools were carried back to the farmers in the counties by the cooperative councils of the States. In other States the schools resulted in the organization of cooperative councils for the promotion of all marketing work within the State. The average attendance at the cooperative-marketing schools was 175.

General marketing information was also disseminated among farmers through the press or by radio. Bulletins designed to give the latest and most authentic data on marketing methods as revealed through research conducted on various commodities were published. Extension workers also helped farm women in marketing their surplus home-grown products. Local leaders experienced in marketing activities were given special training in the standardization of products and were of considerable assistance in aiding extension agents to carry out marketing plans.

Extension workers aided in the organization of 942 new cooperative-marketing associations during the year. Although the number organized was somewhat less than the 1,021 associations organized last year, the membership of 83,700 exceeded by approximately 13,000 the membership organized into associations last year. These

associations and the 2,269 that had been previously organized were aided in the solution of their management problems. The volume of business carried on by all cooperative-marketing associations organized with the aid of extension agents was valued at $233,202,395, of which $14,611,350 was the estimated profit from sales or savings realized from cooperative purchases. Approximately 453,000 farmers adopted improved marketing practices as a result of extension activities during the year.

FOODS

Extension activities in food selection, preparation, and preservation continued to develop along the same fundamental lines which have been followed for several years, but with growing support and increasing success. An important object in extension work with foods was the teaching of the farm family to produce on the home farm sufficient milk, eggs, meat animals, vegetables, fruits, and other foods to provide proper storage facilities for foods, to home cure the meat, and to can fruits and vegetables in order to insure an adequate year-around food supply. Another object was to develop the income-producing possibilities of the home farm after the family's needs were satisfied. This was done especially in the Southern States through teaching not only the production but also the grading and packing of vegetables and fruits, dairy and poultry products, the standardization of canned products, preserves, jellies, pickles, and baked goods, and the disposition of the surplus on home-demonstration club markets to private customers. Independence, business training, more attractive homes, and other opportunities were realized by countless farm women and 4–H club girls as a result of the efforts of extension workers.

An interesting method of combining training in meal planning, food preparation, table service, and etiquette with hospitality and in some instances with increased income was devised by means of what were termed "community meals." These were object lessons designed to show men as well as women and girls that a simple, well-selected and carefully prepared meal properly served is more enjoyable than a meal of miscellaneous, poorly selected foods.

A few States developed unique methods of buying foods for home makers in localities where the size of the farm income, nearness to town, or heavy household responsibilities made it economically sound to purchase meats, canned goods, and fruits and vegetables, as well as staple dry groceries. This work resulted in substantial money savings as well as greater satisfaction for the money expended.

Interest in food activities increased materially among 4–H club members, according to the reports of extension agents. A considerable advance in the enrollment of club members and in the number completing their work with foods was noted during the year. This was partly due in some States to reorganizing the content of 4–H club work with foods, but all States increased their efforts to show both girls and home makers the value and the interest of this important line of work. In addition, local leaders of food clubs received more careful training.

Extension agents reported that farm women stimulated food production by staging 53,490 demonstrations in home gardening, 10,950 in home dairying, and 30,100 in home poultry raising. Club members completed 66,850 demonstrations in home gardening, 29,470 in home dairying, and 56,900 in raising poultry, according to the reports of all extension agents.

Bread-making habits were improved for the first time under the direction of extension workers by 54,000 farm women; 59,100 adopted better practices in cooking meats; 96,400 in cooking vegetables; and 67,650, in preparing dishes made from dairy products. The family food supply was budgeted for the first time by 20,100 women, and 93,200 improved their practices of preparing meals. Altogether, there were 260,220 home makers who were reported as having adopted at least one of the better practices of food preparation taught by the extension agents.

In food preservation, 92,650 women were reported as accepting improved practices of preserving fruits and vegetables and 33,660, of preserving meats and fish. Better food-storage facilities were provided by 20,600 homes. The amount of food products which it was reported had been preserved consisted of 20,178,000 quarts of food canned, 1,098,000 pounds of fruits and vegetables dried, and 16,366,000 pounds of meats cured. In all, 144,290 homes were reported as having adopted improved practices in food preservation.

NUTRITION

As the working efficiency and contentment of people depend largely on

their health, extension workers gave much thought and effort to teaching farm women, men, and children to establish good food habits through the proper selection and preparation of foods. Improving the milk supply in quantity and quality, conducting milk-for-health campaigns, encouraging a more adequate and sanitary food supply in local stores, serving well-planned meals at community gatherings, improving the menus in local orphanages and almshouses, establishing better facilities for the school lunch, sponsoring well-child conferences, and directing or encouraging health-education work in local schools were among the activities reported by rural women with the help and instruction of extension workers.

The results of dietary studies with groups of farm families and surveys of the food habits of school children were made available in several States during the year. These studies showed that in many rural districts an unbalanced dietary still exists and confirmed the evidence furnished by a preliminary checking of the food-selection score card by home makers and 4–H club members and the analysis of menus actually served. These sources of information emphasized the need for a greater use of milk, vegetables, and raw foods in most districts, for reducing the use of excess starchy foods, fats, and sweets in many districts, and for increasing the amount of animal proteins in a few districts.

Training in the principles of child guidance and habit formation resulted in increased attention to the psychological problems involved in child feeding. This work met a long-felt need, for many parents, although knowing their children's requirements, are checkmated by the negative attitude of the children. The preparation of essential foods required by the food-selection standard received still more attention than in the past, since improvement in foods habits, depends largely on forming new likes for the proper foods. Contests in salad making, bread making, and the preparation of milk dishes added interest and incentive to the work.

The growth work of 4–H clubs, which has for its objectives the improvement of food and health habits and the correction of physical defects, was more rapidly extended to 4–H members of clubs other than foods clubs, and especially to members of boys' clubs. In several States the entire club membership was encouraged to maintain food-selection score cards, to have periodic physical examinations, and to enter local and State health contests. More training in growth work was given to local leaders during the year and more 4–H team demonstrations were reported in subjects related to growth and health.

There were 47,000 demonstrations in nutrition conducted by rural women and 62,800 by 4–H club members. As a result of these demonstrations and supplementary methods designed to widen their sphere of influence, 73,340 women balanced their family meals according to approved methods, 40,770 women prepared better school lunches, 2,760 schools were induced to serve a hot dish or school lunch at noon, and 35,080 homemakers adopted better practices in child feeding. A total of 211,990 home makers improved nutrition practices during the year.

CLOTHING

Clothing work has always been popular among farm women and girls, and although certain phases of it received less attention during the year than in 1927 the net result was an increase in the number of home makers that became interested in the better-clothing practices being taught by extension workers. Clothing selection, construction, and renovation continued to be leading phases of clothing extension activities, followed closely by adult wardrobe planning and costume designing.

Although the intense interest of farm women in clothing work was undoubtedly due to the desire to be well dressed and to reduce the family clothing expenses, home demonstration and 4–H club agents reported that the project also was effective in creating among farm women a desire for home betterment along other lines. It was also successful in developing community leadership among farm women who had acted as local leaders in clothing activities.

With the assistance of extension workers 320,200 home makers accepted the demonstrated clothing methods, among which were the selection of clothing with reference to attractiveness, suitability to the wearer, health, and economy; the making of dress forms; time-saving practices in garment construction; use and alteration for personal requirements of commercial patterns; selection of dress goods; principles of designing and sewing; use and repair of the sewing machine and its attachments; planning layettes; repair and care of furs; and

the keeping of clothing accounts and budgets. Other activities intimately related to the clothing work were hat making, home dyeing, selection of shoes and stockings and their relation to the costume, the purchase of bed and table linens and draperies, and tests for distinguishing various kinds and grades of textiles. Correct posture and the use of well-fitting clothes and comfortable shoes were also emphasized in clothing activities.

Fashion and fabric shows were held in several States to teach the importance of color, line, design, and tastefulness in clothing as factors to be taken into consideration. One State reported a considerable advance in demand for assistance in remodeling clothes, indicating an increased interest in economy. This State conducted the project in 14 counties, which resulted in savings to the farm women estimated at from $1,000 to $5,000 per county. In another State, in which records have been maintained of the value in money to farm women influenced to change their practices through extension teaching, a saving of about $2,500 was reported in clothing construction, renovation, and use of foundation patterns, and more than $3,000 in the cost of millinery.

During the year farm women carried on 74,600 demonstrations in the various phases of clothing activities and 4-H club girls completed 162,000 demonstrations. Improved practices in the selection and construction of clothing were adopted by 133,380 women, 81,000 adopted better practices in cleaning and renovation, 64,770 in adult-wardrobe planning, 60,000 in costume designing, 48,230 in millinery, 35,100 in children's wardrobe planning, and 14,740 in infant-wardrobe planning.

HOME MANAGEMENT

During the year greater emphasis was placed on the managerial phase of home management and the development of the farm woman's ability to make wise decisions concerning the economic, social, or physical aspects of her home. A general trend was also noted toward the increased use of time schedules, wise employment of leisure time, keeping of household accounts, and the efficient ways of doing routine household tasks.

Home demonstration agents reported that the principal factors to be taken into consideration in carrying on home-management extension were (1) the lack of permanent homes, (2) limited farm incomes, (3) individual differences found in the homes, and (4) lack of information regarding real needs of the home. Home demonstration agents are making rapid headway on the last problem in practically every section of the country. In the West, fact-finding surveys have obtained valuable information on housing and equipment and the minimum cash household budget required for the farm home. Home-management programs were then based on the needs discovered through the surveys.

The farm home maker displayed much interest in having her home made attractive, restful, colorful, and efficient. Some of the subjects upon which home demonstration agents and local leaders assisted the farm woman were kitchen arrangement; saving of steps; personal efficiency; time schedules; wise use of leisure; decorating of floors, walls, and woodwork; color schemes for all rooms; household economics; selection of equipment; laundry methods; economical buying; family relationship; and house-cleaning methods. In kitchen improvement, contests were reported as continuing to result in the largest number of women adopting improved practices.

Housekeepers' conferences for the purpose of analyzing special household problems were reported as being popular among farm women. Such conferences met for all-day discussions and the home makers demonstrated the performance of various household tasks in the quickest and best way. Definite conclusions are reached by the participants after considerable discussion of the merits of various methods.

The magnitude of the problem that confronts the rural family in the wise choice and selection of electrical equipment was also appreciated by agents in sections where power was available. One State reported that 1,800 new power lines were established in rural communities. A truck equipped with an electrical farm plant was sent through the State. Extension rural engineers demonstrated the installation and upkeep of the electric system, and home-management extension specialists discussed the choice and care of household equipment. Conferences were held in another State to discuss the wise use of electric power and to solve the problems presented.

The methods of conducting home-management extension were more successfully carried out through the single-practice plan. This method is based on the idea of singling out of the voluminous subject matter on home

management one or two definite practices and, through the campaign method, convincing a large percentage of women in a community that they should adopt this practice. Examples of such practices are the installation of a pump and sink with a drain in every kitchen and the raising of working surfaces to the correct height for the farm woman. Certain home-management skills were demonstrated, such as the best way to wash dishes and how to make a bed the quickest and easiest. One method of demonstrating skills was with the use of teams of adult women. The demonstration on fatigue showed that it was possible to save 506 steps in performing a simple household task, such as making a salad. Much of this work was conducted as a result of local-leader training at some central point. Exhibits of kitchen equipment and arrangement played their part. County exhibit contests were held, and local leaders took an active part in preparing such exhibits.

That large numbers of rural women accepted the advice of extension agents is indicated by the fact that 99,150 home makers adopted the better practices taught. Adults carried on 33,940 demonstrations in home management, and 4–H club members completed 16,300 demonstrations. Some type of household account work was carried on in almost every State, influencing 8,690 women to make budgets and keep accounts. A total of 22,750 women followed a systematized plan of household work; 47,500 obtained additional labor-saving equipment; 25,000 planned and rearranged their kitchens for convenience; and 14,250 followed improved laundry practices. Expensive equipment, such as lighting, water, and sewage-disposal systems, were installed in many homes. Reports show that 4,903 sewage-disposal systems, 3,586 water systems, 589 heating systems, and 3,584 lighting systems were installed during the year.

HOUSE FURNISHINGS

The principles of good home decoration and furnishing were applied by thousands of rural women under the direction of extension workers during the year. Women were helped to make their homes attractive, comfortable, and artistic with the exercise of a little ingenuity and little or no expenditure of money. Color schemes were worked out for the home; women were taught how to finish furniture, walls, floors, and woodwork, what draperies, rugs, and wall paper to select, and how to make suitable curtains from inexpensive materials. Poor pictures were discarded in favor of pleasing ones; lamp shades, slip covers, and other accessories were made, furniture upholstered, and similar improvements made to make the furnishings in the home more harmonious. 4–H club work achieved some excellent results in home-improvement activities and centered around what is termed the "own-your-own-room" club. The room which the club girl beautified with the help of the extension agent or local leader was an inspiration to many homes. Farm women extended the improvement to the remaining rooms in the home after the daughter had demonstrated what could be done at little cost.

Excellent plays telling the results of home-furnishing work were written by community women and presented at achievement-day programs. Good growth and development were also featured in home-furnishing improvement through an intensive study of mattresses and their relationship to posture and good health. Exhibits were made that proved helpful in interesting other farm women in the cozy and attractive home. Tours were held to demonstration homes where the best practices were presented.

That women and girls appreciate information on making the home a pleasant and restful place is shown by the fact that more than 141,000 homes were improved through home-furnishing activities. Club members completed 36,270 demonstrations and adults 35,050 demonstrations. More than 79,300 women adopted improved practices in selecting and arranging articles for the home; 50,300 repaired and remodeled home furnishings; and 48,000 put into practice the best methods of treating walls, floors, and woodwork.

HOME HEALTH AND SANITATION

Activities in home health and sanitation were correlated very closely with the activities of clothing, home improvement, home equipment, home management, and especially nutrition. Agents made encouraging progress in convincing farming people that the conservation of health is just as important as treatment for the cure of the sick. Phases of this objective which were given attention by agents, in cooperation with local physicians, dentists, and nurses, were the care of teeth, eyes, and ears; personal cleanli-

ness; good posture; healthful food; proper recreation; prevention of colds; and sufficient sleep. Proper sanitation, also a highly important factor in the retention of health, was emphasized by advocating such measures as good ventilation; screening to keep out flies, mosquitoes, and other insects; eradication of rats and ants; introduction of adequate provisions for bathing; use of pure drinking water; general clean-up of the farm premises and outlying dump heaps; and the sanitary disposal of garbage, trash, and sewage. Curative measures for the sick, home nursing, first-aid treatment, invalid diet, and similar measures were encouraged by extension workers in cooperation with health agencies and welfare workers with effective results. Food habits were improved through demonstrations in growing, cooking, and conserving the proper foods.

More than twice as many 4–H club members as adults participated in health activities. Club members completed during the year 59,350 demonstrations in the various phases of health and sanitation, and adults carried on 25,390 such demonstrations. The recommended health practices were adopted on 94,220 farms; on 15,090 farms sanitary closets or outhouses were installed; screens were placed in 11,350 homes; and on 23,670 farms other practices of controlling flies, mosquitoes, and other insects were followed as a result of the educational efforts of extension agents. Altogether improved health and sanitation practices were introduced in 85,470 homes.

EASTERN STATES

The Eastern States, one of the four divisions into which the administrative work of the office is divided, includes Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia. Florence E. Ward continued as regional agent representing the office in its cooperative relations with these States.

The problem of producting more home-grown roughage for dairy cows again received major attention from county agents and specialists in the Eastern States. The growing of alfalfa hay, the improvement of pastures, and, in a smaller way, the growing of sweetclover were emphasized in nearly every Eastern State as a means of cutting down feed costs as well as general production costs. The high cost of limestone, coupled with some winter-killing, was the chief factor which seemed to deter farmers from growing alfalfa.

The number of farmers who had their cows tested for tuberculosis increased during the year. This is a gratifying indication of the increased interest that farmers are showing in the production of milk of higher quality. About 2,600 purebred dairy sires were purchased last year as a result of the teachings of county agents and specialists. This number is 600 more than the previous year. Likewise, there also was a much greater interest in herd-improvement association work, agents reporting that more than 100,000 cows were tested for production last year. In line with this need there was greater recognition of the desirability of organizing a more simple herd-improvement association. Many dairy herds in the East are made up of a small number of cows, and because of the expense of membership these small herds may not warrant membership in the usual type of association. Therefore, some so-called short-cut testing associations were developed which seem to be more economical. In most instances the farmer member took his own weights and samples, and these were collected by some agency or sent by mail to the local creamery or milk station or the county agent's office. Here the testing was done and the records sent back to the farmer. In some instances this work was done for as little as 10 cents per test per cow.

One of the larger problems which engaged the attention of county agents, dairy specialists, and agricultural economists was the adjustment of milk production to seasonal demand. This has been particularly pressing for those areas which have depended upon the New York City fluid-milk market, and Vermont and New York, for instance, have considered this one of the most important of the current dairy projects. There seems to be particular need for increased milk during the fall and winter. Consequently, farmers were taught to fertilize their pastures, improve the quality of their hay, raise some green feed to supplement pastures, feed grain when the pasture begins to get poor, freshen cows in the fall, and feed more heavily during the fall months.

The work in poultry was marked by the spread of the grow-healthy-chicks campaign to nearly all the Eastern States. This campaign features a well-organized attempt to teach farmers from five to eight simple practices of sanitation and management, including

the starting with disease-free chicks in order that chick losses may be reduced to a minimum. This type of campaign has been very successful. Records from several thousand farm cooperators show that in growing several million chicks the mortality rates decreased 15 to 25 per cent or more. The poultry specialists and agents also directed their attention to attacking another large problem—the profitable winter management of the flocks raised from these chicks. In this connection, the control of chicken pox appeared to be an important problem. Extension agents recommended the inoculation of pullets a month or so before they are placed in the laying house, thus preventing later infection and a slowing down of production when eggs are highest.

A less common but interesting project in poultry featured the programs of a few county agents where turkey growing has become a large enterprise. Thus the county agent of Kent County, Md., reported that he had 24 demonstrators who showed the most modern and profitable methods of raising turkeys. This work was featured by the annual county turkey tour in Kent County, which was attended by 800 people. Farms with 1,000 and 1,500 turkeys were visited and methods and equipment used were observed.

Extension work in fruit growing, centering largely in the production of better apples, was marked by continued effort to improve the practices and control of pests and diseases. The so-called spray service, featured in several of the Eastern States, again was most effective in carrying to the farmer information on methods of control at the most critical times so that a higher percentage of control was obtained.

A novel feature of this horticultural extension work was the apple top-working campaign carried on in the six New England States. These States agreed that to get higher quality apples only seven standard varieties should be recommended for commercial planting. In addition, this campaign sought to teach people to graft or top-work trees of other varieties to these standard varieties. In Maine alone, 500 orchardists cooperated in top-working nearly 20,000 trees to the standard "New England seven" varieties. Over 2,000 more farmers were reached with the extension work in fruit growing than during the preceding year.

Extension work in vegetable gardening has been marked in the past by much individual service. Last year, however, extension specialists and agents succeeded in some instances in attracting state-wide or district-wide attention to large problems common to the industry as a whole. Thus, in Massachusetts, they were particularly successful in teaching the truck and market gardeners the value of liming the soil, so that in many areas the countryside was white in the spring because of the application of many thousands of tons of lime by vegetable gardeners. In a similar way vegetable-gardening specialists and agents in New Jersey and Maryland emphasized the need for earlier planting of home-grown, stocky tomato plants. The evidence was so conclusive that this comparatively simple practice resulted in net increases of 2 to 3 or more tons of tomatoes per acre that extension agents had little difficulty in getting a widespread adoption of this practice in a comparatively short time.

In line with the growing recognition of the need for more data on economic facts as a basis for determining an extension program, the extension specialists in farm management and marketing, as well as several county agents in Massachusetts, joined last year in a survey of vegetable and truck-gardening farms in order to find the type of organization, size of business, use of labor, and cultural practices best suited for the most profitable production of vegetables.

There was no decline in teaching improved methods in the production of potatoes. County agents reported that nearly double the number of farmers influenced last year were influenced during the year to spray or dust potatoes for diseases and insects and that 6,500 farmers planted improved seed for the first time. Although the effort revolved about an increase in yields and consequent reduction in the cost of production, the need for producing a better quality of potatoes was not overlooked. Indeed, this was a feature of the potato campaign carried on in several counties of New York. Three-hundred-bushel or four-hundred-bushel potato clubs served as added stimulus to getting farmers to realize the need for producing potatoes at a profit and for producing something which will compare well on the local markets with potatoes from other sections.

Although about the same number of county extension agents—200—reported work in forestry, the number of farms on which forest practices were adopted increased 2,000. From the reports of agents, it appears that

the reforestation of areas and planting of farm wood lots received the most attention, although the project of wood-lot management grew in importance.

Forestry work will earn increasing support in the Eastern States as both country and urban people appreciate the part that the forests must continue to play in eastern agriculture. New Hampshire joined New York in the employment of assistant county agents in charge of forestry extension work by placing such an agent at work in two adjoining counties. The significance of the work can be better understood when it is known that in these two counties there are 306,222 acres of woodland and woodland pasture on farms. With the employment of such agents the scope of the teaching broadens. Thus a survey was undertaken to determine the most economical and profitable means of producing maple sirup and sugar, collecting spruce gum and tree seed, harvesting Christmas trees, fuel wood, pulp wood, and handling saw logs.

An interesting project in forestry extension which was featured in New Hampshire is the 4–H forestry club work. In all 139,075 white-pine seedlings were planted by the 135 club members enrolled in this work. Ninety-eight boys in the State spent 2,305 hours improving 78 acres of white pine. One hundred and five club members busied themselves making 129 wood collections. During the past year 529 club members were enrolled in 62 forestry clubs.

Most significant of recent trends in extension work was the greatly heightened interest in developing programs of extension work which aim to increase the total incomes of farms. This was one of the urgent needs in rural life. Farm incomes should be large enough to insure that a farm family can live better and more comfortably, and that rural children may have a better education and be helped to become more favorably established in life. Survey after survey shows that many farms produce less than $1,000 net income. One covering 1,477 farms in the North Atlantic States shows the average total farm receipts to be $3,208, the farm expenses $2,114, leaving only $1,094 to pay the farmer for his labor and for all household expenses. Such low returns too often mean a bare living and extreme self-denial, insufficient timely medical attention, lack of educational opportunity, a maximum of household labor, and a minimum of comfort, relaxation, and leisure. In order to help rural people earn more and to live better, extension agents must study the prevailing farm organizations, ascertain what incomes these produce, and determine with the people what readjustments in the size or volume and organization of a farm business should be made to enable the operator to expand or add farm enterprises so that incomes will be brought up to a desirable amount.

The opportunities for these readjustments, expansions, or additons must, of course, be known. These must be based on detailed economic facts. Data on market needs, area trends, future needs and opportunities, cost of changes, possible profits—all must be gathered and studied that safe recommendations and readjustments may be made.

Maine, Connecticut, Massachusetts, Vermont, and New York led in building such programs. Extension agents in these States pointed out to rural people and other extension workers that the problem of greater incomes is the most common and the greatest of all questions affecting the farms. They indicated, for example, that to continue merely to urge the small dairyman to improve production per unit is only part of the problem. He may need to milk from 12 to 20 cows instead of 6 to 8; to keep 300 hens instead of 40; to grow cash crops bringing in perhaps $1,000 or more in order that his farm may produce at least from $4,000 to $5,000 gross income annually.

The continued progress in the improvement of extension methods in the Eastern States was most gratifying. During the year there was a big increase in the number of well-planned projects of the campaign type. These brought about a larger and more widespread adoption of better practices. They stimulated many agents and specialists to see the need for better teaching methods and for reaching more people. They brought bigger gains to the farmers and farm women. Circular letters, circulars, exhibits, meetings, committee work, and other extension means and agencies were improved and given wider use. During the year there was a very great development and improvement of the circular letter. At least eight of the Eastern States made wide use of printed, illustrated circular letters. These were most favorably received by a large circle of rural people.

During the year 967 extension agents were employed in the Eastern

States, as compared with 883 the previous year, a gain of 84 men and women. Table 1 shows the distribution of the various extension employees and the gains or losses in numbers.

TABLE 1.—*Number and distribution of extension employees in Eastern States, 1929*

Employees	Number employed	Gain or loss
Directors and assistant directors	20	3
County agent leaders and assistant leaders	16	−1
Home demonstration leaders and assistant leaders	21	0
Club leaders and assistant leaders	24	2
Specialists	250	1
County agricultural agents	266	−5
Assistant county agricultural agents	36	14
County home demonstration agents	192	29
Assistant county home demonstration agents	20	6
County club agents	104	28
Assistant county club agents	18	7
Total	967	84

The number of county agricultural agents remained about the same. A substantial increase in the staff of county home demonstration and club agents was realized. This expansion was necessary to care properly for the opportunities for helping rural women and boys and girls. Funds made available under the Capper-Ketcham Act during the year largely made this expansion possible.

The increases in the numbers of assistant agents was due, probably, to the increased demand on the part of the people for extension assistance. However, the employment of assistant agents meets another problem outlined in the following report from one of the Eastern States.

> We maintain from 6 to 10 assistant county agents in the field at all times so that they may become experienced and qualify for positions as county agents when vacancies occur. These assistants are placed with county agents in counties with large programs and where organization and methods are well advanced. As they become acquainted with the work they are gradually given increased responsibility so that when vacancies occur they are able to assume the duties of county agents with little difficulty. Frequent visits are made by supervisors to counties having assistants to observe their progress and guide their development.

That directors and supervisors of county extension agents are alert to the need for supplying trained extension workers, and their continued professional improvement is shown in the following statements from the reports of two eastern county agent leaders:

> There is a growing need, as the agent's job grows, for opportunity for study. This same thing applies to all extension agents. It is difficult, otherwise, to keep up with the change in conditions and in methods and new information. The job is growing and better and better trained persons are needed for the work.
>
> Extension agents are interested in some recognized system of professional improvement which will give them opportunity to better equip themselves to lead the industry which they help. * * * Supervisors must see to it that county boards of agriculture fully appreciate the benefits which will accrue to extension work and rural improvement from this better preparation to provide proper leaves of absence for agents and substitutes during such leaves.

During the past year home demonstration work in the 12 Eastern States was carried forward in 4,086 communities under the direction of 194 home demonstration agents and 41 specialists. This work was supervised by 12 State leaders and 8 assistant State leaders and district agents. Four of the States—Connecticut, Delaware, Maine, and New Hampshire—now have home demonstration agents in every county. There are four urban agents in this section working in Paterson, N. J., and in Buffalo, Syracuse, and Rochester, N. Y.

Agents and specialists were assisted by 16,665 local leaders who served without compensation as officers and project leaders. New Hampshire reported a much greater use of local leaders during the past year. Training schools for leaders functioned in quantity in all counties of that State.

Emphasis was placed on reaching a greater number of women and more of the young rural home makers. For instance, Worcester County, Mass., reported reaching three times as many young mothers in 1928 as in 1927. Hampshire County, in the same State, provided a goal of 1,000 young women to be aided through extension work in 1929.

There was considerable evidence of a tendency to use other means and agencies for teaching in addition to lectures and demonstrations. Results show that the total number of homes in which improved practices in home making were adopted last year was 244,195, as compared with 165,453 during the previous year—an increase of nearly 50 per cent.

Boys' and girls' club work in the 12 Eastern States was an integral part of the extension program in agriculture and home economics and, to an increasing degree, made its contribution to the improvement of farming and

home making in the area. There were in the Eastern States 146 supervisors and agents who devoted their efforts to 4–H club work. This number included one State leader and two county club agents in West Virginia who were employed to work with negro boys and girls.

An outstanding intention of the Capper-Ketcham Act was the advancement of 4–H club work and the progress resulting from the increased funds thus provided began to be evident in a gratifying way. This act, which became effective July 1, 1928, is responsible for an increase in the number of club agents. In 1928 there were 145 as compared with 109 in 1927. The 4–H club enrollment for the 12 Eastern States showed an encouraging increase from a total of 80,663 different boys and girls in 6,686 4–H clubs in 1927 to a total of 85,722 in 7,210 clubs in 1928. The 1928 enrollment included 49,335 girls and 36,387 boys.

The present status of club work of the East reflects the fine and devoted leadership of club leaders, large numbers of whom have been continuously in the work since its inception. Ten of the leaders have been in the work nine years or more. It is recognized in every Eastern State that the future development and expansion of boys' and girls' club work depends to a large degree upon ability to obtain, train, and hold local volunteer leadership, so as to carry on a thoroughgoing, connected, and continuous program. The earnest attempts in this direction have resulted in an increased number of local leaders and an increased amount of time devoted by each leader to the work. Effort has been made, and with some success, along the line of building the club program into the general extension program in such a way as to make club work a real factor.

CENTRAL STATES

The Central States consist of Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin. G. E. Farrell continued in charge of administrative contacts of the office with this group of States.

The year was one of steady progress in all lines of extension endeavor. Prominent among the developments noted during the year were the cordial relationship maintained with farmers' cooperative associations and organized groups of farm women, strong legislative support in several States for a program of financing county extension agents from public funds, increased interest in applying available economic information to farm adjustment, improvement in cooperation of extension workers and agricultural high-school teachers, and expansion of home demonstration work. Extension programs were based on more effective studies of farm and home conditions; better extension supervision was maintained; plans of work were more definite; there was more pronounced cooperative effort in developing well-balanced programs of adult and junior work; and public indorsement of extension activities was more widespread.

The fertility of the soil, even in the most fertile sections, occupied more attention and time of the extension organization in 1928. The clover and prosperity campaign in Missouri was continued. Lime and legume campaigns were conducted in all States. The acreage of alfalfa in Minnesota was increased from 50,000 acres in 1918 to 600,000 acres in 1928. The area of sweetclover planted as a result of extension work in that State reached 200,000 acres. Seed of known variety and origin was recognized as essential to yield. Each of the group of States worked out with the assistance of the extension service plans for the certification of seed. Associations of farmers assumed the responsibility for the inspection and certification of seed. County extension agents acquainted the farmers with the program for the production of certified seed and instructed them in the practices of planting, roguing, and harvesting.

Sound educational cooperative effort in both marketing farm products and purchasing farm supplies in this area received the support of the extension service. The associations organized with the assistance of the extension service did almost $1,000,000,000 worth of business and added more than 23,000 new members. More than $12,500,000 worth of farm supplies were purchased cooperatively. Farm-management extension increased in volume and importance. The experimental plan in Illinois for the employment of farm-management accountants to supervise the record keeping and to make analyses completed its 3-year contract period in 1928. More than 225 farmers continued the work for the period. A reorganization for another 3-year period was completed. The increased labor income over the 3-year period, resulting from record analyses, justified an expansion of farm-management activities in this

State. The increased emphasis placed on the farm-management program in Ohio and Kansas and the addition of farm-record work to the correspondence courses in Minnesota furnished evidence of the wider use of records as a basis of farm adjustment. The agricultural outlook for 1928, issued by the department, was supplemented in each State by a State outlook. A large number of meetings were held to place the outlook before the farming people. The attendance and interest at these meetings exceeded that of any previous year and resulted in the application of economic information to the adjustment of farm enterprises by an increased number of farmers.

According to the reports of county agricultural agents, continued support was given to the improvement of livestock through educational efforts in insect and disease control, the introduction of high-grade or purebred stock, home growing of feeds, improvement of pastures, and breeding. Attention was also given to such phases as livestock management and sanitary production and care of milk. The purebred sires campaign which has been in progress for several years brought increasing results. In 1926, 7,772 purebred dairy and beef sires were placed on farms. In 1927, the number so placed was increased to 8,620 and in 1928 to 10,071. The campaign for the eradication of tuberculosis in livestock, carried on as a joint undertaking between the regulatory forces of the State and the educational forces represented by the extension service, continued during the year, but there was a slight decrease in the total number of animals tested. There were 171,000 animals reported as tested in 1927 and 160,000 in 1928. The culling of poultry to eliminate low producers has reached the stage where it need no longer be demonstrated. The extension problem was to train one or two people in each community to do the culling for neighbors and friends either for a small fee or as a community enterprise. More than 2,252,000 head of poultry were culled, and 1 out of every 4 was discarded as unprofitable laying stock. Herd-improvement associations for cow testing increased from 672 in 1927 to 803 in 1928. Plans for reducing the cost to the farmer of cow-testing work were initiated in several of the States. The work in livestock sanitation, especially in connection with swine, reached the stage where small farrowing houses on clean ground for the production of litters free from roundworms were generally accepted. The grow-healthy-chick campaign was still in the demonstration stage. Turkey production in the Corn Belt has been revived as a result of the campaign for improved sanitary methods of managing the poults. Four turkey raisers in Walworth County, S. Dak., followed the sanitary practices recommended and raised 1,406 turkeys from 1,631 poults. Heretofore, the loss of young poults had been responsible for the elimination of turkey raising in many areas. Feeding schools relating to poultry, fat stock, and dairy cows continued to occupy an important place in the livestock extension program.

The war on prairie dogs, gophers, and ground squirrels continued. The Brown County campaign in South Dakato is typical. Fifteen hundred pounds of poison bait distributed over 24,500 acres at a cost of $156 proved so successful that the county commissioners decided to abandon the bounty method of control and in this way reduced the rodent population and saved the county several thousand dollars. Insect-pest control reached the point where it was largely a matter of advising the farmers of impending outbreaks and assisting them in organizing for immediate action.

In agricultural engineering extension workers demonstrated the installation of water systems, the repair of farm machinery and gasoline engines, the method of making hay, and the new combine harvester. The use of the 18-inch plow for covering cornstalks in corn-borer control was demonstrated in the corn-borer areas of Ohio, Michigan, and Indiana. The trend in this area was toward the increased use of power per man on the farm. The extension service was called upon to advise the farmer regarding the cost and economical use of electric power in farm operation and to provide him with facts to determine the extent to which it should be used. The housewife was greatly benefited by this power for washing, lighting, pumping water, refrigeration, and the operation of the convenient household devices, which reduced the drudgery and added to the family's comfort in many homes. A total of 9,400 poultry houses was built or remodeled to increase the income from the farm flock, and 9,130 farms were cleared of stumps and boulders to square out fields and conserve farm machinery. Erosion control through terracing increased in Indiana, Illinois, Missouri, and Nebraska.

Marked progress was reported in the further development of leadership of farm women in analyzing rural needs and in planning and carrying to completion programs of home and community betterment. Of particular interest was the expansion of the home demonstration force as a result of increased funds made available under the provisions of the Capper-Ketcham Act. Thirty county home demonstration agents and one assistant county home demonstration agent were added to the staff during the year. Several factors of outstanding import which served to strengthen home demonstration work were (1) agricultural adjustment conferences of state-wide or county-wide nature at which farming people studied economic data and, on the basis of such knowledge, made recommendations regarding program of work, (2) consistent studies of basic home and community conditions to provide a foundation for determining needed programs of work, and (3) greater use of data obtained during personal visits to farm homes while making surveys for use in extension studies carried on cooperatively by the department and the State extension services.

Extension activities were carried on with 284,920 farm women in 720 counties of the Central States. During the year 4,670 groups of farm women with a membership of 126,000 were organized to receive the benefits of extension teaching. This was a wholesome growth over the previous year when 4,020 groups with 60,000 members were organized.

The increased use of local leaders both in counties having home demonstration agents and counties without agents made it possible to meet in part the widespread growing demand of farm women for subject-matter assistance and for direction in improving their farm homes. The broadening influence of local leaders manifested itself in county-wide organization of demonstration clubs and in the federation of county clubs for a better understanding of home problems. During the year 17,633 local leaders were trained by or gave aid to the county home demonstration agents in organizing and directing groups desiring help, in planning home programs based upon local needs, and in carrying such programs to successful completion.

The home demonstration program was planned to bring about a wider use of better practices in the farm home and to develop among farm women well-defined standards of desirable home and community life. Thus, home demonstration agents were concerned not only with the number of garments made, the number of families reporting improved food habits, and similar quantitative measurements of their efforts, but also in improving the judgment exercised by farm women in such matters as food selection, use of color and line in clothing, home furnishing, landscape gardening, and other matters of home responsibility. An important forward step was the effort made to aid farm women in realizing the need for a long-time program and also for a broadened program to include not only the mechanics of housekeeping but also projects concerned with cultural growth.

The largest part of the program for the farm home maker in the Central States was concerned with foods and nutrition, clothing, health, home management, and household furnishing. Farm women were taught to study the dietary needs of the family, to plan food budgets for the entire year, and to grow the vegetables and fruits required. Corrective diets were planned, and farm women were helped in prenatal and postnatal feeding, in overcoming underweight, overweight, and constipation, and in other phases of nutrition. The selection of materials for clothing and of ready-made garments received increased emphasis, as did sewing, millinery, renovation, alteration of patterns, dyeing, and the use of sewing-machine attachments. Home-management and household-furnishing activities centered around the improvement of the farm home through more efficient kitchen arrangement, use of modern kitchen equipment, refurnishing of rooms, house planning and remodeling, and refinishing of old furniture. The use of household accounts, budgets, and time and labor schedules were also phases of the work designed to decrease waste in expenditure of money, effort, and time. Advice was given regarding health habits and practices in the home and on many phases of sanitation. Healthful diets, exercise, and recreation were encouraged. Farm women's camps continued to increase in number and to meet a deep-felt need in the lives of farm women. For the first time one or more camps were held in each of the Central States.

Boys' and girls' 4–H club activities increased substantially over the previous year. A total of 213,869 boys and girls were enrolled in 15,773 organized 4–H clubs in 1928. This enrollment exceeded by 18,030 the

number enrolled in 1927. Of the boys and girls enrolled, 75 per cent completed their demonstrations. The total enrollment consisted of 85,159 boys and 128,710 girls, a gain for the year of 5.6 per cent for the boys and of 11.7 per cent for the girls. Several States made a determined effort to increase the percentage of boys in the total enrollment. Eight States reported an increase in the percentage of boys who were enrolled and five States a decrease. A study of comparative enrollments for each year since 1923 reveals an increase of 69 per cent during the period. The percentage of club members completing their work increased from 60 in 1923 to 75 in 1928.

The enrollment by projects shows that there was little or no change in the projects carried on by the States. Both girls and boys were enrolled in each project. The six projects which attracted the largest enrollment of boys were dairy cattle, swine, poultry, corn, potatoes, and beef cattle, in the order named. The girls enrolled in largest numbers in clothing, food preparation, food preservation, poultry, house furnishing, and home gardens. The relative rank of projects based on the enrollment for the years 1925, 1926, 1927, and 1928 shows a steady growth in interest in dairy cattle and forestry. Interest in swine decreased, and the other projects remained in about their relative order.

One of the encouraging developments during the year was the increased interest in the leadership project. Indiana, Kansas, and Minnesota reported gratifying progress in this work, and in some of the other States it was being considered or just started. Older boys and girls who have completed a certain number of years of club work are eligible. The club member enrolls in this project in addition to the production project. It has proved to be one means of holding both boys and girls in club work for a longer period of years and has also been a means of preparation for adult leadership in club work in later years. The fact that certain States have selected their delegates to the national 4–H club camp from members engaged in this project has added an impetus to this work.

The 4–H forestry project instituted in Wisconsin and developed in certain other States enjoyed a satisfactory growth. Ohio, Michigan, and Minnesota added this project to their lists, and other States carried on forestry along a single line such as windbreaks or shelter belts. The extension foresters in the above-named four States gave considerable time to this project, and each prepared subject-matter material for club members. The greatest development took place in Wisconsin where the assistant State club leader was transferred to be junior extension forester. A State forestry camp was held in this State where forestry instruction was given to the club boys attending.

Extension agents and local club leaders continued to look with favor on judging teams and demonstration teams. Training was given to 2,335 judging teams during the year, an increase of 332 teams over last year. Two judging contests of national significance and one international in scope were held during the year, in which judging teams from the Central States participated. All but one of the Central States were represented at the National Dairy Exposition in Memphis, Tenn. All but one sent representatives to the noncollegiate livestock-judging contest at the International Livestock Exposition in Chicago, Ill. Nebraska sent a 4–H club dairy-judging team to represent the United States at the international dairy-judging contest in England in July, 1928. Demonstration teams, too, were trained to present before the public demonstrations of better practices in agriculture and home making. A total of 6,337 teams were selected and trained in 1928. Extension agents found them a valuable means of popularizing and extending club activities to all sections of their counties. The use of public exhibits showing results obtained in club work was again an important factor. Such exhibits were made at 1,431 community and 1,021 county fairs. A definite trend was noticed toward placing increased emphasis on the annual club week or short course at the agricultural college. Each State reported holding events of this nature. The club camp also continued to play an important part in the club program. A total of 572 camps were held, with an attendance of 34,655 club members.

The extension budget for the Central States for the fiscal year ended on June 30, 1929, amounted to $7,718,682. The personnel on this date consisted of 16 extension directors and assistants, 49 county agent supervisors and assistants, 880 county agricultural agents and assistants, 25 home demonstration supervisors and assistants, 200 county home demonstration agents

and assistants, 63 4–H clubs supervisors and assistants, 109 county club agents and assistants, and 431 subject-matter specialists.

SOUTHERN STATES

The Southern States administration division includes the States of Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, and Virginia. J. A. Evans, assistant chief of the office, acted as regional supervisor for these States during the year.

Severe storms and floods occurred during the year in portions of Florida, Georgia, Alabama, South Carolina, and North Carolina, entailing disaster to the crops and livestock of thousands of farmers. The occurrence of the Mediterranean fruit fly in Florida caused panic and severe loss throughout a large area of that State. For most of the year the usual extension programs were entirely disrupted because of the necessity for using extension workers in emergency fruit-fly control work. A severe summer drought in Texas, Oklahoma, and Arkansas, and to a lesser extent in the other Southern States, also cut short the growth of all feed crops and materially injured cotton, especially in the States mentioned. But for the timely appropriation by Congress of a large sum of money for seed, feed, and fertilizer loans to storm and flood-stricken farmers in the southeastern coastal-plains area, thousands of them would probably have been unable to plant their usual crops in the spring of 1929. The appropriation was effectively administered through the seed-loan office of the United States Department of Agriculture, with the cooperation of the agricultural and home demonstration agents in the areas concerned. It proved a great help to many thousands of farmers and also to the business interests of these sections, not alone because of the financial aid extended to those who could hope for aid from no other source, but also because this evidence of governmental concern restored hope and revived the morale of people that were sunk deep in apathy and despair.

During the year county extension workers in the Southern States officially visited 306,188 different farms and 156,280 different homes one or more times in carrying on their work. They received 1,399,862 office calls and 834,796 telephone calls from people seeking information and advice regarding some phase of agriculture and home economics work. They prepared 108,910 news articles for the local or State press and wrote 1,738,594 individual letters regarding some phase of agricultural or home-economics work. Extension exhibits were made at 2,893 community fairs and 1,581 county fairs; 239,576 method or result demonstration meetings were held, with a total attendance of 3,707,327 men and women; and 47,016 general extension meetings were held in addition, with a total estimated attendance of 3,360,183.

Program making was given increased attention. Every effort was made to fit extension programs to the needs of the communities. Most of the States now have county advisory boards of agriculture, made up largely of experienced demonstrators and interested business men. They assist the county agent and specialist in working out county and community extension programs. In this work production costs, price trends, and outlook and other statistical information is being more and more utilized. Usually such advisory boards are divided into enterprise groups, with subcommittees meeting with the county agent, supervisors and specialists as necessary to work out the details of an economic production and marketing program for the respective enterprises. Extension programs were cooperatively worked out by extension agents with the people concerned in 26,494 separate communities. In carrying out adult extension work the agents were assisted by 41,161 county, community, and local leaders.

A trend in Southern extension work has been to place greater emphasis on the importance of well-planned definite result demonstrations, with accurate cost records showing the net profit or loss resulting. More effort and thought were expended in establishing "demonstrations that demonstrate" and in getting accurate cost and sales data from them than ever before in the history of the work. South Carolina, for example, has for several years required project leaders, specialists, and agents to have carefully outlined and located result demonstrations, definite in methods and objects, in connection with any extension project undertaken and as a part of the demonstration requires accurate cost and sales records. As a result the service now has invaluable farmers' records on every phase of agriculture which prove beyond question that it pays to use the methods which the college through its exten-

sion service recommends. To this ability to prove the facts as to profit or loss on demonstrations and to the effective publicity given these result demonstrations is largely attributed the attitude of the county legislative delegations, causing them in the face of millions of dollars of crop loss, uncollectable taxes, and general demoralization in the storm and flood-stricken area of that State to appropriate money for county agents' work in 1929 in every county. In Louisiana, counties in the flood areas so impoverished that they were compelled to borrow money for all ordinary county expenses, borrowed the additional sums necessary to maintain county and home demonstration agents. Along with the trend toward more definite demonstrations and records is noticeable also one toward confining extension publicity to results of demonstrations and definite achievements.

Soil improvement was a major extension enterprise in almost every county in the South. No permanent soil improvement is usually possible until erosion is stopped. Terracing is therefore the basic step in soil-improvement programs. This is being realized as never before by farmers, bankers, and commercial bodies, and as a result the terracing campaigns have been aggressive and effective. One county agent in Arkansas reported that 150,000 acres had been terraced the past year. In the entire territory agents reported the construction of 44.112 terraces last year under their supervision, designed to prevent erosion on 1,326.681 acres of land. The Oklahoma director considers terracing a leading project in that State.

The second phase of soil-improvement work in the South was the use of legumes as soiling and winter-cover crops. Great progress was made in securing general use of the wide range of summer and winter legumes available for soil improvement, hay, and pastures. Alfalfa, sweetclover, Lespedeza, vetch, Austrian peas, cowpeas, and velvetbeans were extensively grown for soil improvement in the various States. Many thousands of legume demonstrations were conducted during the year and the widest possible publicity given to the results through field meetings, circular letters, and news stories.

Pasture-improvement work was an important extension activity. In Mississippi, for instance, it is estimated that there were ten times as many acres seeded to permanent pasture grasses as had been seeded altogether in the preceding 10 years. Similar interest in permanent pastures was found in the other Southern States.

Interest in dairying increased in all the States. Gratifying progress was made in replacing scrub bulls with good dairy sires and in introducing high-grade or purebred dairy cows. The agents reported 709 dairy-bull associations organized with their assistance during the year and that 7,430 farmers were assisted in obtaining purebred dairy sires. The extension service endeavored to keep the dairy movement in the South on a safe and sensible basis. It made a special effort to increase the production of home-grown feeds and to instruct the farmers to feed properly. There was a decided renewal of interest in beef cattle in the South. Extension work in this field was largely a matter of securing better type sires, in establishing permanent pastures, and in establishing demonstrations to prove that the cut-over and idle lands of the coastal plains may be profitably pastured with beef cattle. As a result of one pasture tour in North Carolina, 35 farmers planned new pastures. Farmers in the Southern States were assisted in procuring 1,538 purebred beef bulls during the year.

Extension work in swine production emphasized economic production and marketing. This involved home-grown feed and pasture, breeding, sanitation, correct feeding, and timely marketing. This was a leading project in every State. The hog breeding and marketing program in most of the States provided for two litters per sow per year, fed out and marketed in March and April and in August and September, respectively. These months are usually the periods of top prices. Many hog breeding and feeding associations were formed during the year. Approximately 9,000 swine result demonstrations were carried out and completed by adults during the year, the majority being economic feeding and marketing demonstrations. Ton-litter contests were also conducted in several of the States.

The poultry industry is growing to significant proportions in the South. Extension agents in all the States gave producers valuable assistance in all phases of production and marketing. Contacts were made with more farm people, including boys and girls, in carrying on poultry extension projects than in any other phase of extension endeavor. Breeding, housing, sanitation, culling, feeding, and general

farm-flock management were the principal lines along which poultry-extension work was carried on by demonstrations and other means during the year. Extension agents worked to secure economic production rather than the expansion of the industry. Car-lot sales of poultry ran into millions of dollars in value the past year.

The 5-acre cotton contests carried on in many of the States served to stimulate interest in better methods of production and in the production of better staple cotton. It is estimated that in Georgia alone these demonstrations stimulated the purchase of 40,000 bushels of pedigreed cottonseed from outside the State after the State supply of purebred seed was exhausted. All States reported that yields of cotton are being gradually increased and the cost of production per pound decreased through the adoption of better methods and soil improvement. The production of longer and more uniform staple is increasing, but failure to receive an adequate premium for the better staple is a decided detriment to progress in this field.

Extension work in marketing was concerned largely with effecting a closer tie-up between economic production and marketing of the various products. The importance of standardization and grading and of group selling was effectively shown by demonstrations and otherwise in relation to many different products. In all, 534 cooperative-marketing associations were organized upon the suggestion or with the counsel of the extension service; 815 previously organized associations were also aided. These associations bought and sold supplies and products valued at millions of dollars and were able to secure appreciably better prices and effect substantial savings for their members.

4–H club work in the Southern States continued to grow in 1928. The enrollment in boys' clubs was 130,534 and in girls' clubs 185,585, a total of 316,119. Of this number 188,091 turned in complete records. Reports show continued improvement in organization and instruction of members. The community plan of organization in which all boys and girls belong to a single club with project groups maintained for instructional purposes is gradually spreading throughout the territory. This plan places the responsibility for the organization and conduct of the clubs largely upon the members. Learning to do by doing and learning to lead by leading is the theory advanced by the advocates of the plan. Experience has proved that it works well in all of the Southern States that have tried it.

Boys and girls put on demonstrations in the Southern States in more than 50 projects. Splendid results were obtained, although in many sections climatic conditions were unfavorable. The average yield of corn made by 16,062 boys throughout the territory was 35 bushels per acre. Several of these boys made more than 100 bushels on their acres. The average yield of seed cotton of all boys reporting in Alabama, Arkansas, Georgia, and Mississippi was 1,138 pounds per acre. In Anderson County, S. C., 295 boys made a bale of cotton or more to the acre. Of these boys 193 made an average of 702 pounds of lint cotton to the acre. This is an outstanding result.

While the boys did such excellent work on the farms, the girls did as well in the homes. A total of 59,710 demonstrations in food preservation, 51,307 in nutrition; 29,616 in house furnishings; 38,086 in beautification of home grounds; and 15,527 in home management, and many other demonstrations show conclusively that the girls are not idle.

In the work with farm women, home gardens, food preparation, preservation, nutrition, home beautification, kitchen equipment, clothing, and house furnishings continued to be important. Home demonstration agents in North Carolina and other States cooperated effectively with health departments in combating pellagra and other nutritional diseases. They materially assisted farm women to increase the family income through their poultry, home gardens, food preservation, and home dairy work in hundreds of thousands of instances. The home-improvement and home-beautification projects more than ever enlisted the interest of farm women. In 1928, 37,389 farm women carried out plans for the beautification of home grounds; 90,652 women were enrolled in home-garden clubs; 31,610 in home-dairy work; and 59,396 in home-furnishing clubs. Home health and sanitation attracted an enrollment of 54,188 women, and 77,188 women and 127,586 girls were enrolled in clothing work. Altogether, 122,563 girls and 96,740 women were enrolled in and instructed in food preparation, and 99,372 women and 107,761 girls in food preservation. The work of home demonstration agents showed encouraging results in improved health and living conditions in the rural sections of the South.

Extension work in the Southern States is now firmly established in the confidence of all classes of citizens more than ever before. Increased State appropriations and county support are evidences of this. During the year 35 men and 94 women agents were placed in new counties, and 44 assistant agents were added. Nineteen additional specialists were also employed. The total number of supervisors, specialists, and county workers in the South on June 30, 1929, was 2,308, an increase of 192 during the year. Of the county workers, 942 were white men agents; 649, white women agents; 167, negro men agents; and 125 negro women agents. Practically all new agents appointed are graduates of standard agricultural colleges. Most of the agents now in service have completed work for a degree or have training equivalent to that required for a degree. The average salary of county agents was higher in 1928–29 than in previous years. Counties were more than ever willing to appropriate liberally to secure well-trained efficient agents. However, the problem of meeting the competition of still higher salaries offered by commercial concerns to the best trained and most efficient agricultural agents so as to retain them in the service is one that is giving the directors much concern. In practically every Southern State there are a number of counties on the waiting list for county and home demonstration agents which the college can not now supply for lack of available funds to supplement the county appropriations.

WESTERN STATES

The Western States include Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming. W. A. Lloyd, who is in charge of the cooperative relations of the office with these States, was granted a year's furlough beginning October 25, 1928, to organize and direct extension work in Hawaii. C. B. Smith, Chief of the Office of Cooperative Extension Work, took direct charge in this region during Mr. Lloyd's absence.

During the year extension programs were planned and executed in 5,004 communities under the guidance of extension workers. In carrying out these programs excellent assistance was given by 24,306 farm men, women, and older boys and girls who volunteered their services as county, community, or local leaders. Of this number, 18,886 leaders worked with adults and assumed the responsibility for placing demonstrations, training local demonstrators, holding field meetings, and conducting tours. Assistance was given by 5,420 leaders who helped 4–H club members to carry on their demonstration activities. Volunteer leaders were given extension training at 2,198 meetings at which the attendance was 31,720. Reports indicate that increased dependence was placed on local leadership in enlarging the radius of extension influence. The county extension agent utilized every effective device in making contacts with farming people. Office days were maintained, during which 770,000 requests for assistance were received and information supplied; more than 185,000 visits were made to about 94,000 farms to give help to the farmer; and 32,400 visits were made to 19,200 homes to aid the farm home maker. A total of 31,000 news items regarding demonstrations and other extension activities and informative articles were supplied to the farm press. More than 22,900 method and result demonstration meetings were held, with an attendance of 469,500; and farmers' institutes, extension schools, and short courses had an enrollment of 97,000.

Continued emphasis was placed on the careful collection of facts and the determination of actual conditions for use in supplying a more accurate basis for community, county, and State extension programs. As a result extension programs have become increasingly definite in outlining the work necessary to solve the problems of the western farmer and home maker. Program making has undergone a continual process of evolution in this region. At first programs were planned by local community groups. Later this method was superseded by the county economic-conference plan, and the farming groups were organized on a county-wide basis for each enterprise represented. This brought under consideration at meetings not only good production practices, but also the outlook for the various enterprises. When the home demonstration workers organized groups of farm women on a similar basis, certain standards were set up as essential for a contented American farm home. To maintain these standards a minimum net annual farm income—in many sections about $1,200—was necessary.

As a result of this evolution in approaching the rural problems of the West, sounder extension programs have been prepared which take into consideration not only good production practices and the trend of the various enterprises, but also the size of the individual farm business that must be conducted to pay all farm expenses and return an income to the farm family that will enable it to maintain at least the minimum standard of living determined.

The farm extension activity that touched the greatest number of farmers in the West was the control of destructive animal and insect pests. The control measures recommended by extension workers to eradicate rodents and other animal pests were put into use on 50,310 farms, and the control operations affected almost 17,000,000 acres. On more than 3,000 farms also modern methods were introduced to combat grasshoppers and other insects on about 251,800 acres. Of the farmers in this region, an additional 10 to 12 per cent have been interested annually in pest control.

In dairying, which was next in importance during the year, approximately 39,000 farmers acted upon extension advice. This was approximately 12 to 15 per cent of the total number of dairy farmers in the Western States. These activities related primarily to the control of tuberculosis. Reports indicated that 23,580 farmers decided to test their animals for this disease. Agents assisted 1,600 farmers in obtaining purebred sires, 1,650 in obtaining high-grade or purebred females, and taught 1,645 farmers how to cull the unproductive animals from their herds. Improved practices in the sanitary production and care of milk were adopted on 4,470 farms, and 3,940 farmers fed better-balanced rations. Through extension effort a total of 38,765 farms put into use one or more of the recommended practices.

Horticultural activities also were popular during the year, especially those relating to the growing of tree fruits and the beautification of home grounds. Approximately 22,400 farmers adopted improved horticultural practices. Here the control of disease was an important phase, but increasing attention was also given to pruning. In connection with cereals 13,500 farmers accepted some improved practice relating to the use of improved or certified seed or the control of such diseases as smut. Demonstrations in breeding, feeding, culling, disease control, and management of poultry were outstanding in many States. Reports show that 18,567 farm men and women adopted better poultry practices at the suggestion of county extension agents. Soil-improvement practices were modified by 12,140 farmers who conserved and improved fertility through the use of lime, home-mixed and high-analysis fertilizers, and cover crops for green manuring. Other agricultural activities which agents encouraged with gratifying results were the growing of legume and forage crops, drainage, irrigation, land clearing, use of better farm machinery, establishment of farm-record systems, marketing, and installation of sewage-disposal systems.

The intense interest of farm women in taking advantage of every opportunity to better their home conditions resulted in increased demands being made for the help of the home demonstration agent. County conferences were held in Colorado, Montana, and Wyoming to give the farm woman a better opportunity to discuss the needs of the home in a businesslike manner and to become acquainted with actual facts instead of relying on general observations on which to base the home demonstration program. Farm women's camps continued to grow in number and interest. California, Colorado, Idaho, Montana, New Mexico, Washington, and Wyoming conducted either county or district camps. Such camps not only afforded rest, recreation, and instruction for the farm woman but served as a popular means of bringing home demonstration work before the general public. Several States reported that the camps were an influencing factor in establishing home demonstration work in new counties.

Judging from the number of practices adopted, clothing, nutrition, house furnishings, home management, and home health and sanitation were the outstanding phases of the work in the West. Clothing activities attracted an enrollment of 25,780 women and 17,700 girls. Agents aided 16,080 women and 7,900 girls in the proper selection and construction of their clothing. Better practices in renovation and remodeling were adopted by 6,380 women and 1,600 girls; 6,410 women and 2,640 girls were assisted in costume designing; 5,700 women and 1,200 girls, in adult wardrobe planning; and 5,430 women and 700 girls, in millinery practices. Farm women and girls made more than 43,500 dresses and coats, 33,150 undergarments, and 8,700 hats in the manner

recommended by extension workers. Altogether, in more than 30,900 instances improved clothing methods were adopted.

In nutrition, very satisfactory results were obtained in getting men, women, and children to add to their diets health-building foods. Demonstrations were conducted in corrective feeding for the entire family, food selection and preparation, and school lunches. Vegetable-cookery contests, milk campaigns, and nutrition clinics were held for the information of the rural home maker. Emphasis was placed on correlating these activities more closely with the home production of milk, fruits, vegetables, and poultry in order that a satisfactory diet for year-round use might be maintained. A total of 18,950 women and 5,880 girls was enrolled in nutrition activities. The efforts of county extension agents in nutrition resulted in the adoption of better practices in 22,480 homes. Work in house furnishings, which included rearrangement and selection of furniture, draperies, and household accessories; refinishing of walls, floors, and woodwork; and other improvements designed to make the home more attractive and comfortable, resulted in the adoption of such practices in more than 12,050 homes. The principal phases of home management were concerned with kitchen arrangement, use of labor-saving equipment, installation of systems for lighting, heating, water, and sewage disposal, and business methods in the home. This work resulted in 10,930 home makers making some improvement in their home-management practices. In teaching farming people better general health practices, special attention was given to correct posture; use of well-fitting clothes, especially shoes; personal hygiene; care of teeth, hair, ears, and skin; home care of sick; and similar phases. A total of 7,790 homes benefited in some manner by extension work in health.

Boys' and girls' 4–H club work made decided progress during the year not only in expanding over a wider territory but in the development of more constructive programs. The total enrollment of 48,230 individual club members was an increase of 9.6 per cent over that of the previous year. A considerable number of club members carried on demonstrations in two or more projects. Of the boys and girls enrolled, 72.8 per cent completed their project activities. The number of 4–H clubs increased from 4,543 in 1927 to 5,603 in 1928. A review of the enrollments and completions of the various projects indicates that livestock projects were the most popular among the boys. Dairy-cattle clubs had an enrollment of 3,156 boys, of whom 2,398 satisfactorily completed their demonstrations; swine clubs enrolled 2,560, and 1,878 completed; and poultry clubs had an enrollment of 2,322, with 1,570 completions. Home gardening also proved an attraction to 4–H club boys, judging by the enrollment of 2,164. Among club girls, clothing was by far the most popular project. Clothing clubs had an enrollment of 17,701 girls, of whom 12,718 completed their work. There were 5,876 girls enrolled in nutrition clubs, 4,285 of whom completed their demonstrations; food-preparation clubs enrolled 4,445, of whom 3,425 completed their demonstrations; and of the 1,342 enrolled in food preservation, 960 brought their work to completion.

On June 30, 1929, there were employed in the Western States 631 extension workers, an increase of 75 over the previous year. The extension staff in this region included 18 extension directors and assistants, 16 county agricultural agent supervisors, 267 county agricultural agents, 60 assistant county agricultural agents, 13 home demonstration supervisors, 103 county home demonstration agents, 2 assistant home demonstration agents, 10 4–H club supervisors, 23 county club agents, and 119 specialists. There was an increase of 31 in the number of home demonstration agents and assistants, an increase of 30 in the number of county agricultural agents and assistants, and an increase of 6 in the number of county club agents. The total amount of the funds allotted for extension work in the 11 Western States was $3,020,044.

HAWAII

In the Territory of Hawaii the extension staff included on June 30, 1929, 1 dean and extension director, 2 assistant directors, 1 extension specialist, 3 home demonstration agents, and 4 county agricultural agents. The total amount of funds allotted for extension work in Hawaii for the year was $44,300.

DEMONSTRATIONS ON RECLAMATION PROJECTS

During the year the office of demonstrations on reclamation projects has been carrying on work cooperatively

with the State extension services on the following projects: Uncompahgre and Grand Valley, Colo.; Minidoka, Idaho; Flathead and Huntley, Mont.; North Platte, Nebr.-Wyo.; Carlsbad, N. Mex.; Newlands, Nev.; Klamath and Umatilla, Oreg.; Belle Fourche, S. Dak.; Strawberry, Utah; and Shoshone, Wyo.. Financial assistance from this office enables the State extension services in the various States where the projects are located to increase their field activities among the project settlers. Each project has an agricultural program that it is following under the direction of an extension agent.

ECONOMICS AND MARKETING

The economic phases of the work were stressed more than ever before. The economic surveys and outlook conferences held on the projects seem to have stimulated more real thinking on the part of the farmers than any other extension activity. In the follow-up conferences which have been held on several of the projects, to check the results of the economic surveys, the outlook material published by the colleges and the United States Department of Agriculture has been used to good advantage. In these follow-up conferences much interest has been developed in working out a fair standard of living for a farm family of five and then selecting some of the typical farms in the community in which the conference is being held and proposing farming systems which would produce the necessary income for such a standard of living. This has been done with full realization that living standards vary not only in the different communities, but in the same community, and what might be considered a desirable standard by one family would not be accepted as desirable at all by another. There has been no thought of trying to outline a standard of living that would satisfy all, but rather to have each community determine the income requirements necessary to provide a fair living standard. The income requirements have varied from $1,000 to $1,500 in addition to what the farm provides. The discussions centering around this subject have been interesting and profitable to all participating in them. In introducing this subject into the economic conferences, the desire has been to help the farmers to realize the needs of a farm family more fully and thereby to create a more active interest on their part in reorganizing their farms on a more profitable basis so that their families may enjoy more of the conveniences of life. These studies have served a useful purpose as a measuring stick for many farmers, in giving them a better idea as to what they might expect in income from a certain size and type of farm.

Marketing is demanding each year more of the time of the field men. The statement is rather frequently made by farmers, "It is not assistance in production we need, but assistance in marketing." The pooling of products for market is becoming quite a common practice on many of the projects. Last year more than 2,900 lambs and approximately 80,000 turkeys moved to market by this method, and fleeces in wool pools numbered about 7,000. The reports of the field men show that the value of products sold cooperatively amounted to $2,106,534, with an estimated saving to the producers of $135,219. On the whole, the pools have been successful, and each year has found a larger number participating in them.

CROPS

The work with crops has made up an important part of the agricultural program. As in the previous year, considerable time has been given to the use of pure seed, soil improvement, and weed control. The pure-seed work has been confined largely to the location of good seed and the disposal of surplus stocks that farmers had for sale. The production of certified seed, due to the encouragement of the field men, is becoming an important enterprice on many farms.

Soil improvement on several of the projects is a major piece of work. The yields of some of the principal crops are not holding up as well as they should, and this is causing some concern. Therefore, with the hope of finding out the cause of the trouble, soil-improvement demonstrations of various kinds have been conducted. In connection with these demonstrations many tons of commercial fertilizers have been used, as well as barnyard and green manures. As a result of this work there is a growing interest in the use of all kinds of fertilizers. No one yet seems to have found a satisfactory explanation for the declining yields.

Controlling weeds has developed into a real problem on the irrigated projects. The demonstrations along this line the past year, however, have

been very encouraging. Chemical weed killers gave good results, especially sodium and calcium chlorates. These chemicals are applied as a spray and are less expensive than most of the other commercial weed killers. Plots carefully treated in 1928, when examined in the spring of 1929, showed that a 90 to 100 per cent kill had been obtained in most cases.

LIVESTOCK

The livestock program changes very little from year to year. Dairying continues to receive more attention than any of the other livestock enterprises, with poultry ranking second. The good prices received for lambs and wool the past few years have kept up a live interest in farm flocks, and with cheaper feeds and better prices for pork products, hogs have again begun to attract more attention.

In the interest of dairy improvement, better feeding, the use of purebred sires, and the elimination of the boarder cow have been emphasized. During the year 191 farmers were given assistance in securing purebred sires, in comparison with 97 the previous year. Nine cow-testing associations were organized, with 3,089 cows under test, with the result that 153 boarder cows were sent to the butcher's block. Better feeding practices were adopted on 271 farms, and better dairy practices of some kind were adopted on 1,504 farms. An increasing interest in dairying continues in spite of the high prices asked for dairy stock.

The major poultry activity has been the care of baby chicks and turkeys, coupled with disease control. The high mortality in the young birds has proved a serious handicap to poultry men. These losses are too often traceable to improper feeding and poor sanitation; therefore, considerable time has been spent in working out desirable rations and suitable quarters. Improved practices were adopted during the year on 682 different farms. The poultry industry continues to enlarge, especially turkey raising, as it has been one of the most profitable farm enterprises.

MISCELLANEOUS

There were enrolled in boys' and girls' clubs 731 boys and 562 girls, or a total of 1,293, of whom approximately 65 per cent completed their work. In carrying on their field activities the field men made 10,872 personal visits to farmers and received 23,300 office calls and 13,274 telephone calls. One thousand news articles were prepared for the press; 16,509 individual letters were written, and 14,186 bulletins were given out to those seeking information. Method and result demonstration meetings held numbered 947, with an attendance of 16,886. Other extension meetings attended by the field men numbered 1,086, at which there were 47,609 people in attendance. Many other activities, such as leaders' training schools, farmers' institutes, extension schools, and encampments, were held as a part of the agricultural program.

MOTION PICTURES

The office of motion pictures continued with the same organization as during the preceding year, with Raymond Evans as chief and C. A. Lindstrom as associate chief. E. J. Kelly, film editor and director, resigned September 11, 1928, to accept a commercial position. The number of employees at the end of the year was 24.

DISTRIBUTION

The demand for department motion pictures in agricultural extension work has continued to run ahead of the supply of films available for circulation. Although 3,527 shipments (11,037 reels) were made by the office of motion pictures during the year, it was necessary to decline applications for about 1,500 subjects because of the inadequate supply of copies. Estimates based on partial reports of attendance at film exhibitions indicate that over 5,000,000 people saw pictures lent by the department during the year. Since an equal number of pictures are circulated by purchasers, it is probable that at least 10,000,000 people saw department pictures in that period.

About four times as many copies of department films were bought during the year by outside agencies interested in the advancement of agricultural information as were made for the department's own distribution. Two hundred and ninety-eight pictures, totaling 418 reels, were bought, educational institutions and foreign governments acquiring the greater proportion. Educational institutions purchased 109 copies, and foreign governments 87 copies.

NEW FILMS

The following new pictures were completed during the year, of which 75 copies are available for distribution from the department:

Rust (2 reels).
Banishing the Barberry (2 reels).
Land Clearing (2 reels).
Bamboos—The Giant Grasses of the Orient (1 reel).
Early Care of Baby Chicks (2 reels).
How About a Combine? (1 reel).
Under the 4–H Flag (4 reels).
Home Is What You Make It (3 reels).
Naturalized Plant Immigrants (3 reels).
The Master Farmer (2 reels).
Traveler's Toll (3 reels).
America's Great Bridge Test (1 reel).

The department now has films on about 250 subjects.

One new film, Naturalized Plant Immigrants, was prepared especially for showing at the Ibero-American Exposition at Seville, Spain. Copies of 25 existing films were prepared and furnished for use at this exposition.

EXPANSION OF WORK

In an effort more nearly to meet the motion-picture needs of extension forces in the States, plans were formulated during the year to produce films in cooperation with State colleges of agriculture. Tentative arrangements were made to begin a 5-year program in Georgia and Alabama during 1930. The plan will be expanded to include other States as soon as practicable.

Preliminary experiments in the production of sound pictures were conducted during the year. At present the cost of sound projection apparatus places it outside the reach of most users of department films. When our experiments or commercial developments have made it possible to place sound-projection apparatus on the market at a price within the reach of our users, the office of motion pictures will be prepared to furnish "talking" pictures.

The use of narrow-width or 16-millimeter film is on the increase. Copies of any of the department pictures may be purchased in this size, and a few such purchases were made by outside agencies during the year. The department has not had funds available to establish a film library for distribution on 16-millimeter stock.

PURCHASES BY OUTSIDE AGENCIES

Table 2 shows the films purchased by outside agencies during the year, arranged by sponsoring bureaus.

TABLE 2.—*Summary of motion pictures purchased by outside agencies, fiscal year 1929*

Sponsoring bureau	Reels	Prints
	Number	*Number*
Agricultural Economics	51	31
Animal Industry	89	55
Biological Survey	7	7
Dairy Industry	13	10
Entomology	15	14
Extension Service	20	14
Federal Horticultural Board	1	1
Forest Service	87	66
Insecticide and Fungicide Board	2	2
Plant Industry	37	28
Plant Quarantine and Control Administration	7	6
Public Roads	56	50
Weather Bureau	6	5
Extension Service, Chemistry and Soils and Public Roads cooperating	27	9
Total	418	298

EXHIBITS

During the year the office of exhibits continued under the direction of Joseph W. Hiscox, with no important changes in personnel. The Washington personnel at the end of the year numbered 27, and that in Alexandria, Va., 9. Emergency employment during the year for varying periods totaled 4, consisting of 1 draftsman and 3 unskilled laborers.

The appropriation for exhibits at State, interstate, and international fairs for the year was $108,800, in addition to which State fairs and other agencies contributed $7,856 to pay transportation and other costs. The department expended $14,102 for the preparation of an agricultural exhibit for showing at the Ibero-American Exposition at Seville, Spain. The total available for exhibits was, therefore, approximately $130,758. In addition, 11 units of the department contributed $1,274 for renovation, repairing, trucking, shipping, and replacement in storage of exhibit material displayed at occasions which do not come within the provisions of the exhibits appropriation act.

PREPARATION OF EXHIBITS

During the year 55 new exhibits were completed, 35 extensively revised, 105 renovated, and at the close of the year 10 booths were in the course of preparation. This is an increase in new exhibits built of approximately 10 per cent.

The improvement of existing exhibits was made one of the outstanding efforts of this year's program. Each exhibit was given close study from the standpoint of value of subject matter and effectiveness of presentation. As a result of this scrutiny 25 exhibits were discarded, leaving 140 in active service, of which 35 were redesigned and revised. For instance, in the exhibit Service of Roads, the value of good roads was illustrated by a model made to take the place of a still picture in the center of the exhibit. In the foreground of the model is a section of a road, part of which is good and part of which is very bad. A model auto-truck moves along the good road at a rapid rate, slows up where the good road ends and comes to a stop in the bumpy road, then moves along very slowly, swaying from side to side as it moves over the ruts and bumps.

The revision of the booth Success in Rearing Chicks is worth noting because it shows how the improvement of exhibits is keeping pace with the demand for more interesting exhibits and also with the development of knowledge of exhibit construction. This exhibit was originally designed as a 3-panel booth, relying entirely on words and illustrations to attract and hold interest. Later it was improved by cutting an opening in the center panel and building on a scene at the rear. This scene was made more interesting by an apparent depth obtained through the use of cut-outs and artificial lighting. When the exhibit was again reviewed this year, after several years' service, it was decided that it was no longer sufficiently effective for present-day needs. The center scene was discarded and a mechanical model substituted which shows the essential factors in rearing poultry. A mechanical apparatus shows the eggs going into the incubator, small chickens passing from the incubator to the brooder, larger chickens from the brooder to the chicken range, still larger chickens from the range to the henhouse, and eggs passing from the henhouse to the table.

Six of the exhibits were revised through the addition of mechanical models as described. Nineteen other exhibits were rebuilt from a structural standpoint, and nine were improved by better arrangement of elements and a reduction in words. The reduction of wording to the minimum was a principle applied in the revision of all the exhibits. In the building of new exhibits a special effort is being made to keep headlines and legends short. In the exhibit Clean Milk Production, now under construction, only seven words are used in the entire exhibit in addition to the main heading.

One general improvement was the equipping of 35 exhibits with flood lights, thus greatly increasing their effectiveness.

The new exhibits which attracted the most attention and were in greatest demand during the year were The Milk Factory and The Brood Sow's Rebellion. Both of these exhibits consisted of representations of animals operated mechanically, synchronized with amplified talks. While exhibits of this type are difficult to build and require the services of an operator whenever they are in use, they are sufficiently effective to justify the cost and effort. In the exhibit, A Brood Sow's Rebellion, compressed air was used in exhibit operation for the first time. This exhibit is in the nature of an act at one point in which first one pig and then another becomes very thin and falls over dead. The deflating process was accomplished by filling the pigs with air under pressure and releasing it at the proper moment in the act. It is believed that further use can be made of air in exhibits where increasing and decreasing volumes are to be shown in comparison or where sounds which can be produced by air are desired. Experimental use is also being made of rubber for certain types of models.

This year's exhibit-building experience points to the need of an experimental section where new ideas and processes can be tried and perfected. Under present conditions the experiments must be conducted as the exhibits are built and when time is short the result must be used whether it is perfect or not.

SEVILLE EXPOSITION EXHIBITS

The exhibit prepared by the Department of Agriculture for the Ibero-American International Exposition at Seville, Spain, was completed and shipped early in January, 1929. In this exhibit the following subjects were featured: Wheat, corn, cotton, tobacco, sheep and wool, hogs, poultry, livestock sanitation, livestock history and development, dairying, better roads, and experiment station work. An attractive illustrated report of approximately 100 pages on those phases of agriculture covered by the exhibits was printed in English, also in Portuguese

and in Spanish, and sent to Seville to be distributed at the exposition. The department exhibit was completed well in advance of the opening date, which was postponed from March 9 to May 9.

EXHIBITION DIVISION

During the past year the office has conducted exhibitions at 74 fairs and expositions throughout the United States. Seventeen carload exhibition groups were required for the circuits, with a total movement of 50,487 miles. There were 24 carload and 44 less-than-carload shipments made from the exhibits warehouse at Alexandria in the outgoing movements, and 21 carload and 38 less-than-carload shipments were received into the warehouse, while 37 carload shipments were made in the field between fairs on the circuits.

The exhibition plan in effect with State and interstate fairs during the past year was the same as had been in practice for several years, by which arrangement the department furnished the exhibits and provided personnel for the management and demonstration at the fairs. Each participating fair deposited in advance a prorated share of transportation cost, provided exhibition space with storage for shipping containers, drayage and labor for unloading and reloading cars, common labor for unpacking, installing, dismantling, and repacking the exhibits, and janitor, watchman, electrical, and such other services as were required to accomplish a creditable display.

The following tabulation is a summary of the value of the cooperation provided by the fairs:

Deposit to cover transportation charges	$7,855.93
Value of exhibition space	17,587.30
Trucking (unloading exhibits)	752.38
Installation labor	706.43
Dismantling	273.40
Trucking (loading exhibits)	$744.92
Miscellaneous exhibit expenses	341.02
Total	28,261.38

Development of accurate information regarding the actual transit time required for the movement of exhibits between fairs has enabled a larger number of exhibitions for each group, which, with careful planning of circuits, has made shorter freight hauls possible, so that the annual transportation cost has been materially reduced. The annual transportation bill for 1926 divided among the participating fairs amounted to $185 per exhibition point. This was cut to $180 in 1927, to $175 in 1928, and to $170 in 1929, a reduction of $15 per fair in three years.

The cost in time and expense of exhibition personnel to manage and demonstrate the exhibits at the fairs has undergone a similar reduction during the same period. In the exhibition season of 1926 there were 35 department exhibitions at State fairs, which required 1,172 days of department personnel time in the field, the cost of which in salaries and expenses was $21,109.35. In the exhibition season of 1928, 40 exhibitions were made at State fairs, or 5 more than in the season of 1926, but the number of man-days required to accomplish them was only 877, approximately 300 days less, while the cost in personnel salaries and expenses was $8,000 less. In 1926, 69 per cent of the salaries and expenses of men assigned to State-fair exhibitions was borne by the bureaus of the department and 31 per cent by the office of exhibits, but by 1928 the bureau portion had decreased to 63 per cent of the total and that of the office of exhibits, although not appreciably greater in money, had increased to 37 per cent.

Exhibitions held during the fiscal year ended June 30, 1929, were as follows:

Place	Occasion	Dates
A. and M. College, Miss.	Dad's Day	Nov. 10, 1928.
Aurora, Ill.	Central States Exposition	Aug. 10–17, 1928.
Baltimore, Md.	Maryland Sheep Improvement Special	Oct. 3–8, 1928.
Do.	B. & O. Better Dairy Sires Special	Apr. 8–26, 1929.
Beltsville, Md.	Dairy Federation Pilgrimage	May 9, 1929.
Birmingham, Ala.	Alabama State Fair	Sept. 24–29, 1928.
Boston, Mass.	New England Sportsmen's Show	Jan. 16–26, 1929.
Brockton, Mass.	Brockton Fair	Oct. 1–6, 1928.
Centerville, Md.	Dairy meeting	Mar. 15, 1929.
Chicago, Ill.	American Farm Bureau Federation Exposition	Dec. 10–12, 1928.
Do.	International Livestock Exposition	Dec. 1–8, 1928.
Do.	Izaak Walton League of America	Apr. 17–20, 1929.
Cleveland, Ohio.	Thirteenth annual convention, National Sand and Gravel Association.	Jan. 9–11, 1929.
Do.	Cleveland Road Show	Jan. 14–18, 1929.
Columbus, Ohio.	Ohio State Fair	Aug. 27–Sept. 3, 1928.
Des Moines, Iowa.	Iowa State Fair	Aug. 22–31, 1928.
East Lansing, Mich.	Farm Convenience Train	Oct. 1–15, 1928.
Florence, S. C.	A. C. L. R. R. Livestock Train	June 15–July 15, 1928.
Grand Rapids, Mich.	Western Michigan Fair	Sept. 10–14, 1928.
Hagerstown, Md.	Hagerstown Fair	Oct. 9–12, 1928.
Hamline, Minn.	Minnesota State Fair	Sept. 1–10, 1928.
Harrisburg, Pa.	Pennsylvania Farm Products Show	Jan. 21–26, 1929.
Do.	Pennsylvania Department of Forests and Waters	Do.
Hartford, Conn.	Connecticut State Fair	Sept. 2–8, 1928.
Helena, Mont.	Montana State Fair	Sept. 22–28, 1928.
Hutchinson, Kans.	Kansas State Fair	Sept. 15–21, 1928.
Jersey Shore, Pa.	Dairy sires train over New York Central Railroad in Pennsylvania.	Oct. 29–Nov. 10, 1928.
Kansas City, Mo.	American Royal Livestock Show	Nov. 11–24, 1928.
Lansing, Mich.	Farm Bureau meeting	Feb. 7–8, 1929.
Lewiston, Me.	Maine State Fair	Sept. 3–6, 1928.
Lincoln, Nebr.	Nebraska State Fair	Aug. 31–Sept. 7, 1928.
Little Rock, Ark.	Arkansas State Fair	Oct. 8–13, 1928.
Long Beach, Calif.	Pacific Southwest Exposition	July 27–Sept 3, 1928.
Louisville, Ky.	Kentucky State Fair	Sept. 10–15, 1928.
Marlinton, W. Va.	Pocahontas County Fair	Aug. 20–25, 1928.
Marshall, Tex.	East Texas Dairy Show	Mar. 4–7, 1929.
Memphis, Tenn.	National Cotton Show	Oct. 13–18, 1928.
Do.	National Dairy Show	Do.
Do.	Annual convention, National Fire Protection Association.	May 13–16, 1929.
Missoula, Mont.	Western Montana Fair	Sept. 19–21, 1928.
Muskogee, Okla.	Oklahoma Free State Fair	Sept. 29–Oct. 6, 1928.
New York City.	Parents Exposition	Feb. 23–Mar. 2, 1929.
Do.	Twelfth Exposition of Chemical Industries	May 6–11, 1929.
Nottingham, England.	World's Dairy Congress	July, 1928.
Omaha, Nebr.	Ak-Sar-Ben Stock Show	Nov. 3–9, 1928.
Orlando, Fla.	Central Florida Exposition	Feb. 10–23, 1929.
Orono, Me.	Highway Conference, University of Maine	Dec. 19–21, 1928.
Pensacola, Fla.	Naval Stores Get Together Meeting	Feb. 21–23, 1929.
Peoria, Ill.	National Swine Show	Sept. 9–15, 1928.
Phoenix, Ariz.	Arizona State Fair	Nov. 12–18, 1928.
Prescott, Ariz.	Northern Arizona State Fair	July 1–4, 1928.
Pueblo, Colo.	Colorado State Fair	Sept. 17–22, 1928.
Puyallup, Wash.	Western Washington Fair	Sept. 17–23, 1928.
Rochester, N. Y.	Rochester Exposition	Sept. 3–8, 1928.
San Antonio, Tex.	International Exposition and Livestock Show	Mar. 1–7, 1929.
Savannah, Ga.	Georgia State Fair	Oct. 22–27, 1928.
Seville, Spain.	Ibero-American Exposition	Mar. 15– , 1929.
Spokane, Wash.	Spokane Inter-State Fair	Sept. 3–8, 1928.
Do.	Sportsmen's and Tourists' Fair	May 14–18, 1929.
Springfield, Ill.	Illinois State Fair	Aug. 18–25, 1928.
Springfield, Mass.	Eastern States Exposition	Sept. 17–22, 1928.
Tampa, Fla.	South Florida Fair	Jan. 29–Feb. 9, 1929.
Timonium, Md.	Maryland State Fair	Sept. 3–8, 1928.
Trenton, N. J.	Trenton Inter-State Fair	Sept. 24–29, 1928.
Do.	Health Show	Mar. 4–9, 1929.
Waco, Tex.	Texas Cotton Palace	Nov. 9–18, 1928.
Washington, D. C.	United States Capital Military Show at Washington Barracks.	Oct. 1–6, 1928.
Do.	Washington Dairy Council	Sept. 3, 1928.
Do.	Scientific exhibit, Washington Building	Mar. 1–8, 1929.
Waterloo, Iowa.	Dairy Cattle Congress	Oct. 1–7, 1928.
Waycross, Ga.	Georgia Forestry Fair	Sept. 14, 1928.
Wichita, Kans.	Southwest Road Show and School	Feb. 26–Mar. 1, 1929.
Yakima, Wash.	Washington State Fair	Sept. 10–15, 1928.

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REPORT OF THE FOOD, DRUG, AND INSECTICIDE ADMINISTRATION

UNITED STATES DEPARTMENT OF AGRICULTURE,
FOOD, DRUG, AND INSECTICIDE ADMINISTRATION,
Washington, D. C., July 1, 1929.

SIR: I submit herewith the report of the work of the Food, Drug, and Insecticide Administration for the fiscal year ended June 30, 1929.

Respectfully,

WALTER G. CAMPBELL,
Director of Regulatory Work.

HON. ARTHUR M. HYDE,
Secretary of Agriculture.

INTRODUCTION

The organization of the Food, Drug, and Insecticide Administration has been further developed during the fiscal year ended June 30, 1929. This administration was created by act of Congress for the purpose of consolidating and placing under one unified control the enforcement of a number of regulatory statutes. It now has assigned to it for enforcement six laws—the food and drugs act, the tea act, the insecticide act, the naval stores act, the import milk act, and the caustic poison act. The two last-named statutes are of comparatively recent enactment. The first four have been in force for many years. Prior to the organization of the Food, Drug, and Insecticide Administration they were enforced by field organizations, operating to a large measure independently of one another.

During the last fiscal year further steps toward brigading field operations under all six acts have been taken. Although a few special units are still maintained for conducting insecticidal, fungicidal, and other tests, and one field station is devoted almost exclusively to work under the import milk act, the field laboratories as a whole have been equipped so that samples of all kinds of products can be analyzed in any one of a number of laboratories. Inspectors have been trained to sample any or all of the commodities covered by the six laws assigned to the administration. These administrative changes have made it possible to widen the scope of the work done by the administration without adding to the cost of operation.

In the first annual report of the administration covering the fiscal year ended June 30, 1928, it was stated:

> In enforcing the six statutes entrusted to it, the administration has attempted to adopt a constructive attitude. Observations through more than 20 years of law enforcement have demonstrated convincingly that only an insignificant proportion of the members of the industries concerned deliberately violate the law. Most of them earnestly desire to comply with all reasonable regulations, not only on ethical grounds but also because it is the part of good business. Recognizing this, the department has chosen to regard the six laws as corrective rather than punitive, and has adopted an advisory-before-the-act attitude by offering constructive suggestions which should enable manufacturers to keep their products in compliance with the law. It has not hesitated, however, to initiate proceedings under the law in those instances where the protection of the consumer or negligence or willfulness on the part of the shipper indicated such action to be proper.

This well-defined policy of preventing infractions of the six laws through cooperation of the industries concerned was adhered to during the fiscal year

1929. It is not a new policy nor one that is original with the Food, Drug, and Insecticide Administration. On the contrary, it is an inheritance from the Bureau of Chemistry, which developed it in connection with the enforcement of the food and drugs act and which, from the very earliest days of the enforcement of that measure, found that a cooperative policy with the food industries, with prosecution and seizure action as a necessary adjunct where educational measures failed, offered a most effective means of affording the maximum protection to the American consumer.

As far back as 1907, the year when the food and drugs act became effective, investigations originally designed to determine violations of the law in connection with the distribution of poultry and poultry products gradually developed into investigations of a highly constructive character, designed to demonstrate to the poultry industry how best to slaughter and prepare poultry and ship it under conditions that would insure its reaching the ultimate consumer in a condition of maximum fitness. The Bureau of Chemistry, with reason, considered that a portion of the appropriation granted for the enforcement of the food and drugs act could properly be devoted to such highly constructive educational operations, not out of any overwhelming desire to further the interests of the poultry industry, but with a well-justified belief that such operations would guarantee the fullest protection to the consumer and therefore be in harmony with the precise purposes of the food and drugs act.

For the same reason special investigations were undertaken on commercial canning processes, and numerous publications from the Bureau of Chemistry reported work carried out with funds appropriated for the enforcement of the food and drugs act that were of the greatest constructive value to the food canner desiring to place upon the market a product which would meet the utmost demands of the consumer and comply with the law in every respect.

This policy, so sound in its conception and so fruitful in its application, was continued by the Bureau of Chemistry during all the period it was engaged in enforcing the food and drugs act and has been adopted as a matter of course by the Food, Drug, and Insecticide Administration in full recognition of its soundness. In harmony with this plan, the specialists of the administration during the last year have gone into commercial plants to explain their methods of detecting the presence of wormy, moldy, or otherwise objectionable material in foods, and warning notices have been broadcast to the trades concerned when their practices have been found to be contrary to the provisions of the law. Such warnings have unhesitatingly been followed by seizure and prosecution when educational means have proved ineffective.

Perhaps the most active campaign of the year was the one launched to prevent deception of the public through the sale of falsely labeled medicinal preparations, particularly the alleged remedies for influenza which appeared on the market in large quantities to meet the epidemic of 1928. When examination showed that a product could not fulfill the curative claims made for it, immediate steps were taken to remove it from the market. Another important feature of this particular campaign was the cooperation developed with the Federal Trade Commission, which is empowered by law to control false advertising, whereas the administration can proceed only against false labeling. As a result of the combined efforts of these two branches of the Government service, the sale of medicines under promises of cures that they can not meet has been greatly curtailed.

FOOD AND DRUGS ACT

The Federal food and drugs act, passed in 1906 and amended in 1912, 1913, and 1919, prohibits interstate commerce or the importation into the United States of adulterated or misbranded foods, both natural and manufactured, beverages, stock foods, and drugs, and of falsely labeled medicinal preparations. It demands also that the net weight of food in package form, except that in very small packages, be plainly stated on boxes, bottles, or cartons.

DOMESTIC FOODS AND DRUGS

Manufacturers and shippers, both individually and collectively through their trade organizations, have greatly facilitated the administration in correcting at the source conditions which if left unchanged would undoubtedly result in illegal traffic in products subject to the provisions of the act. Nevertheless, 1,210 prosecutions and seizures were brought under the act during 1929, as against 1,015 cases in 1928 and 953 in 1927. Table 1 shows the products involved in these cases.

TABLE 1.—*Prosecutions and seizures under the food and drugs act during the fiscal year ended June 30, 1929*

Product	Prosecution	Seizure	Total
Alimentary pastes		1	1
Baked products	11	1	12
Beverages		3	3
Cacao products	10	5	15
Cereals		3	3
Coffee		1	1
Confectionery		5	5
Dairy products:			
Butter	22	98	120
Buttermilk tablets		1	1
Cheese	9	18	27
Drugs:			
Cod-liver oil		2	2
Crude drugs	3	17	20
Remedies	33	276	309
Stock remedies		25	25
Eggs:			
Shell	3	11	14
Frozen	1	3	4
Fish	1	37	38
Flavoring extracts		6	6
Flour		1	1
Fruit and fruit products:			
Fresh fruit	2	7	9
Canned fruit	13	17	30
Dried fruit	3	22	25
Jams, jellies, preserves	19	24	43
Gum		2	2
Meats	2	3	5
Nuts		48	48
Oils and fats	41	9	50
Oleomargarine		1	1
Poultry		75	75
Shellfish	5	10	15
Sirup		1	1
Spices and condiments	1	15	16
Stock foods	62	82	144
Vegetables:			
Fresh	1	3	4
Canned	35	54	89
Vinegar	32	11	43
Water		3	3
Total	309	901	1,210

BAKED PRODUCTS

The 12 cases against baked products were brought because the packages in which they were sold were misbranded, in that they contained less than the label declared they did. Few practices are more costly to the consumer than the sale of short-weight or short-measure packages. Inspectors are continuously on the alert to detect and punish this form of misbranding of all food commodities.

A misbranding of baked products frequently encountered this year is their sale under health claims that are false and misleading.

Another new type of misbranding in the sale of baked products is the use of the term "flavored with honey" on the labels of products that actually contain too little honey to affect the taste. The most that can truthfully be said for these products is that they are sweetened with honey and sugar. Steps have been taken to have these labels changed.

BEVERAGES AND BEVERAGE MATERIALS

A great improvement in the traffic in beverage materials was noted this year, particularly the passing of the once widespread practice of adding water to bottled grape juice and also of adding, without proper label declaration, sugar to various sirups and concentrates. Some abuses still exist, however, notably the traffic in new products constantly coming on the market. Thus many sirups sold as fruit flavored were found on examination to contain very little fruit juice and to be "fortified" with "fruit flavor," much of which was synthetic. Many also contained added acid or artificial color or both and were not concentrated to the degree declared on the labels. When corrective action was taken the manufacturers in nearly every case changed their labels to meet the law. Very few of them changed their formulas so as to increase the quantity of true fruit juice present, however.

The conclusion reached last year that objectionable colors are no longer used in beverage concentrates and flavors was confirmed by a survey made during the year ended June 30, 1929.

CACAO PRODUCTS

Although the quality of cocoa beans imported into the United States has been greatly improved since the Government sent a specialist to Africa to survey conditions there and offer suggestions for improvement, cacao products that fail to comply with the law still appear in interstate commerce. The chief violation is caused by the sale of chocolate coatings that contain fat other than cocoa butter. Proceedings have been instituted against shippers of chocolate coating containing foreign fats and not labeled to show their presence.

CEREAL PRODUCTS

Exaggerated and false claims based on the bran content have been rather generally made for breakfast and other cereal foods. The growing popularity of such products has made a correction of this misbranding important. The administration was somewhat hampered in bringing about the necessary changes in labeling by the lack of a good method for determining the quantity of bran in samples of this character. Methods for the determination of bran in cooked and uncooked wheat

products were devised this year, which has made it possible to take effective steps to remedy this condition.

COLORS

As certain coal-tar dyes may be harmful in foods or may contain harmful impurities, foods containing such colors come under the ban of the food and drugs act. To facilitate the enforcement of this act, by making it easy for bakers, confectioners, and others to use only pure and harmless dyes, the administration maintains a list of harmless coal-tar dyes and examines batches of these dyes submitted for the purpose, issuing certificates of purity for those that pass the test. Two new colors—Ponceau SX and Sunset Yellow FCF—were added to the list of permitted colors during the year, bringing the number of permitted coal-tar food dyes up to 14.

Table 2 shows the quantities of coal-tar food dyes certified during the last five years.

TABLE 2.—*Coal-tar food dyes certified, 1925–1929*

Year	Straight dyes	Repacks	Mixtures	Batches	Number of firms	
					Total	New
	Pounds	*Pounds*	*Pounds*	*Number*		
1925	315,848.0	39,013.79	284,060.00	883	34	9
1926	311,434.5	32,234.00	304,040.22	1,075	38	14
1927	277,044.0	28,844.13	374,804.28	1,172	52	10
1928	273,282.8	15,279.00	310,137.40	1,206	52	5
1929	337,847.5	28,589.25	333,906.57	1,206	62	10

Twelve batches of straight dye and 10 batches of mixtures were rejected during the year.

DAIRY PRODUCTS

Routine inspection of creameries showed that more rather than less high-moisture and short-weight butter was shipped in interstate commerce during the fiscal year than in preceding years. Most of the butter seized was brought into compliance with the law by the owners under court supervision after decrees had been entered. Constant supervision by Federal and local authorities still seems to be necessary to prevent fraud in the sale of butter.

The traffic in cheese also has called for a good deal of attention under the food and drugs act, as many of the samples examined proved to be high in moisture or low in fat, or both. Extremely unsatisfactory conditions in the cheese industry in one of the principal producing sections were brought to light by a survey early this year. Propaganda favoring the sale of "soft" cheese had created a demand for high-moisture cheese, making it difficult for manufacturers of a legal product to compete with the cheaper one. An active campaign to relieve this situation resulted in several seizures of high-moisture, low-fat cheese, most of which, in accordance with the procedure prescribed by the law, was ultimately released to the shippers, who turned it over to processors to be made into processed cheese.

A paper entitled "Malted Milk, a Study of the Action of the Enzymes of Malt Upon Milk Solids During Manufacture" and another entitled "The Microscopic Identification of Malted Milk and Its Flavored Products," published during the year, give the results of two extensive investigations in this field.

DRUGS AND DRUG PRODUCTS

Although a large number of extravagantly labeled medicinal preparations still remain on the market, decided progress in bringing the labels on these products into conformity with the truth marked the fiscal year.

As has been stated, a special campaign was made against the vast array of preparations put out as treatments for influenza, against which, according to the consensus of modern reliable medical opinion, no single drug treatment is known to be effective. Manufacturers took advantage of the influenza outbreak of 1928 to flood the market with menthol inhalers, tablets containing such antipyretics as acetanilid, acetphenetidin, and aspirin, laxatives, nasal sprays, gargles, salves, cubeb cigarettes, etc., none of which constituted an effective treatment for influenza, as claimed. The labelings of more than a thousand preparations col-

lected in the field were considered to determine whether or not the products were being sold in violation of the food and drugs act. When the labeling was of such a character as to justify legal action, immediate steps in that direction were taken. As the number of products involved was very large and the personnel available to give consideration to them was limited, it was decided that instead of attempting to remove all stocks of any one misbranded article from the market by seizure proceedings, a single consignment of each article would be seized, in the belief that the manufacturer would thereupon remove from sale other outstanding stocks of the misbranded preparation. In practically every instance this was done. In a few instances, however, it was necessary to follow the first action with additional actions in order to rid the market of the misbranded products. In addition to the corrections effected by direct seizure action, a large number of less flagrantly illegal labels were brought into compliance with the law through the voluntary action of the manufacturers.

The so-called malaria remedies also received special attention this year, a preliminary survey having shown that a large number of preparations on the market labeled as treatments for malaria did not contain enough cinchona alkaloids and that the directions did not specify a sufficiently large dose or provide for the use of the preparation for a period of time necessary for the eradication of the disease. Several manufacturers at once modified their formulas and labels to provide for a competent treatment for malaria. A few preparations were discontinued or the references to malaria were removed from the labels. Several seizures of preparations of this type were made because upon analysis it was found that their compositions did not justify the label claims.

The survey on antiseptics begun in 1926 was continued. In connection with this survey, a number of preparations, particularly dentifrices, labeled as treatments for pyorrhea and other gum diseases, have been given consideration. A few court actions, based on misrepresentations in connection with these diseases, are pending. For the most part, however, manufacturers have made satisfactory revisions of labels, including deletion of unwarranted therapeutic claims, without the compulsion of seizure action.

Manufacturers of standard pharmaceutical products during the last year gave a great deal of attention to the labeling of their preparations to assure truthfulness and accuracy. The names of a large number of products, such as "heart remedy," "liver stimulant," and "indigestion tablets," have been changed to indicate the composition rather than the disease condition for which the preparation might be used. The manufacturers have gone so far as to materially modify their catalogues. These voluntary revisions by the manufacturers of pharmaceuticals have been of great assistance in connection with the consideration of proprietary preparations of similar compositions, by removing the excuse that similar unwarranted titles are being used by the pharmaceutical manufacturers. The pharmaceutical manufacturers also, through their contact committees, have continued the study of accuracy in the manufacture of certain medicinal preparations and methods for their analyses.

Some manufacturers have taken advantage of the general public interest in vitamins to exploit preparations as sources of vitamins when the facts do not warrant it. The administration has attempted to put a damper on unwarranted labelings of this character, seeking as far as possible to induce the manufacturers to make their own investigations and limit the statements on their labels to demonstrable facts. Among the articles known to be particularly rich in two of the vitamins is cod-liver oil. Because of its unpleasant taste, many manufacturers have sought to extract its contained vitamins and incorporate them in some form not unpleasant to the palate. In nearly all of such products examined this effort has not been successful. Such preparations are not entitled to be called "cod-liver-oil extract" preparations. The administration has succeeded in having eliminated from the labeling of many of these preparations all reference to cod-liver oil or cod-liver-oil extract.

The administration has been particularly concerned this year with the products sold to farmers as remedial agents for livestock and poultry. Many worthless preparations offered as treatments for various diseases of the lower animals have been removed from the market or their labels have been so modified as to render them no longer in violation of the law. Such diseases as contagious abortion of cattle, necrotic enteritis of hogs, fowl cholera, diarrhea of chicks, coccidiosis, roup or diphtheria, chicken pox, gapes of chicks, blackhead of turkeys, and distemper and heaves of horses

annually cause farmers large economic losses. Taking advantage of this situation, unscrupulous manufacturers have put out preparations labeled as treatments for these diseases, which are in fact ineffective against them. The farmer has no way to determine for himself, except by actual trial, the efficacy of these preparations, and such trial may mean a serious loss, if not financial ruin.

Attention has been given also to products labeled as worm expellers, mineral mixtures, egg-laying tonics, stock tonics for increasing milk production, livestock conditioners, etc., to determine whether or not they are truthfully labeled.

In connection with the physiological effects of drugs, studies of methods for examining and standardizing them have been conducted. The administration provides official standards for the five important drugs for which the United States Pharmacopœia provides biological-assay requirements. These official standards have been distributed not only to manufacturers in this country but also to official investigators in Belgium, England, Poland, Canada, and France.

An extended investigation of ergot of rye has been made. As a result, suggestions looking to the improvement of the official methods for the manufacture of official ergot preparations will be made.

The investigation of anesthetic ether, begun some years ago, was continued, and an effort put forth to prevent the distribution of substandard ether. The development of peroxide and aldehyde in ether after its manufacture and packaging is a problem which has not yet been satisfactorily solved by the manufacturers.

As a result of an investigation in connection with a campaign against adulterated and misbranded lactobacilline preparations, improved media have been devised for the examination of commercial acidophilus and bulgaricus preparations. Also a new method has been found for the examination of certain commercial lactobacilline preparations which consist of flavored mineral-oil jelly in which the lactobacilli are suspended. As the examination of such preparations offers special difficulties, it is expected that the method devised will facilitate the determination of the numbers of viable lactobacilli in them. On the basis of the results obtained in the examination of commercial samples, the administration has been able to effect a marked reform in the labeling of *Lactobacillus acidophilus* and *L. bulgaricus* preparations.

EGGS AND EGG PRODUCTS

By and large, shell eggs shipped in interstate commerce now call for little regulatory action. This is due in large measure to the strict supervision exercised by State and city officials in the important egg-producing States, most of which have enacted special legislation to prevent the shipment of unfit eggs. Nevertheless, each year brings some infractions of the law, calling for continued careful checking up on interstate shipments. Several shipments of incubator rejects that had not been denatured were intercepted and diverted from use in making a dried-egg product during the fiscal year.

Periodic surveys of stocks of frozen eggs in eastern warehouses and examination of representative samples revealed no abnormal conditions. Investigation of the purchasing plants farther west, however, indicated that unsanitary conditions still existed and improper raw material was being accepted. Upon the information gained during this survey, several lots of decomposed egg products were embargoed by State officials, and several interstate shipments were seized at their destination.

FISH

An unusual feature of the year's work on fish was a survey of two large fish piers in the East. Certain conditions, such as too infrequent cleaning of the pier, a rather disorderly arrangement of equipment, and the use of forks and carts instead of mechanical conveyors, were pointed out as factors militating against a legal pack. A later survey showed that most of the changes suggested by the administration had been made.

A preliminary survey of sardines packed on the Atlantic coast indicated that the industry had relapsed into certain unsatisfactory practices which it was thought had been entirely eradicated by the constructive work done during several seasons. Seizure action was necessary in many cases. A second survey of the canneries showed a material improvement. The passage of the Maine sardine law this year presumably will reduce the work on this project formerly required of the administration.

Although one of the largest salmon packs ever put up in the Pacific North-

west was packed in 1928, fewer seizures of lots containing decomposed fish were made than in any preceding year. Nearly all the salmon canneries had installed new fish bins at the beginning of the season, and they made a strenuous effort to speed the handling of the fish from the nets to the cannery. They exercised great care also in keeping the canneries and equipment clean. The principal difficulty encountered in the sale of salmon this year was caused by misbranding. Mackerel canned in California also was marketed almost invariably under labels which gave the impression that it was salmon. As this canned fish could be sold at a low price, the salmon packers objected to the type of labeling employed. The administration, in cooperation with the Federal Trade Commission, induced many of these packers to change their labels.

FLAVORING EXTRACTS

It was found that low-strength and flagrantly misbranded flavoring extracts were being put out by several firms. Investigations showed that the failure to reach the declared strength was probably due in part to lack of knowledge of solubilities of vanillin, coumarin, and citral in the various menstruums used and in part to faulty manufacturing technic. When their attention was called to these findings, the manufacturers at once took steps to change their labels or their formulas, or both.

A method for the determination of citral in flavoring extracts was tested, and the results were reported to the Association of Official Agricultural Chemists.

FRUITS AND FRUIT PRODUCTS

Comparatively few lots of the unusually large shipments of fruit from the Pacific Northwest in 1928 contained spray residue that might be harmful to consumers. The washing equipment, much of which has been developed and installed in cooperation with Federal and State officials, has proved most effective in removing spray residue. The few lots that were found to be contaminated were removed from the channels of trade and held until properly cleaned.

The close watch over canned fruit which conditions during the last few years have shown to be necessary resulted in the seizure of many lots that were excessively wormy and in stopping at the source other shipments which were in violation of the law. Much assistance has been given canners of cherries and other small fruits in perfecting methods for culling out wormy and moldy material.

The systematic work begun in 1927 to control the shipment of insect-infested figs and fig products was continued throughout the 1928 packing season. Hundreds of samples of figs were examined in California, both at the San Francisco station and at the commercial packing houses. New methods for the detection of insect infestation were devised, and the packers were shown how to use them. In spite of the unfavorable conditions due to insect activity and poor growing conditions, marked progress was made in preventing the shipment of wormy and moldy figs from California.

Because of these efforts also the character of the stock used in making fig paste has greatly improved. With the assistance of the Government specialists, manufacturers of fig paste have developed their methods of sorting and culling the stock and testing the finished product to such a point that the fig paste going into interstate commerce this year is the purest paste ever produced.

A nation-wide survey of preparations consisting of pectin, in either dry or liquid form, flavored with true fruit or artificial flavors, sometimes with and sometimes without artificial color, and of gelatin dessert powders showed that many of these articles are labeled in such a way as to lead consumers to believe that they are real-fruit products. Furthermore, many of them will not make jelly as alleged on their labels, jelly being generally recognized as consisting of fruit juice and sugar only. Accordingly, a notice was sent to all manufacturers of these products warning them to phrase the statements on their labels to show plainly that such preparations contain no fruit juice but are merely fruit flavored and perhaps artificially colored, to precede the word "jelly" with the word "imitation," and to declare the presence of an added acid or artificial color.

MEATS AND MEAT PRODUCTS

The discovery that poultry unfit for food was being packed led to a sweeping survey of the industry, which revealed that the culls from the killing houses sometimes consisted of birds that had died of disease or injuries, as well as those which, because of age,

bruises, or deformities, were unsuitable for table use. These culls, packed in barrels, instead of in the boxes used for the better grades, were sold to firms putting up canned chicken products.

Seizure action was immediately instituted against shipments containing objectionable fowls, and at the same time an educational campaign, in cooperation with the Bureau of Animal Industry, the Bureau of Agricultural Economics, local health and food officials, and the trade associations, was begun to show poultrymen the danger of selling diseased poultry. Dressing plants in all parts of the large producing areas were visited, and all packers were warned to destroy every fowl showing evidence of disease. Frequently post-mortem demonstrations were made on carcasses obviously diseased to convince skeptical plant operators that certain signs were proof of a diseased condition. This prompt and concerted action on the part of all the officials concerned—Federal, State, and city—made possible a thorough survey of storage poultry, the destruction of all the unfit poultry found, and the development of a closer inspection of poultry, both live and dressed.

NUTS

Warehouse surveys during the fall make it possible to remove adulterated nuts at a time when they are concentrated in the largest quantities, thus preventing the need for future legal action against small lots distributed over a wide area. Such surveys also prevent the mixing of bad nuts with good nuts, to the consumer's loss. The surveys of nuts during the year, which resulted in 48 seizures, indicated a continuing traffic in decomposed and wormy stock.

OILS AND FATS

Although olive oil when offered for entry into the United States is seldom found to be other than what it purports to be, when repacked for sale in both interstate and intrastate commerce it frequently is adulterated and also short in measure. Usually adulterated oil is sold by irresponsible, fly-by-night dealers, who are difficult to locate. The use of lithographed cans bearing names and brands other than those of the actual shipper, the practice, fairly common among can companies, of selling odd lots of cans, regardless of the manufacturer's name which they bear, and the use of fictitious firm names to avoid detection also add to the difficulty of running down illegal shipments of olive oil. Extreme ingenuity in avoiding detection of fraud is often encountered. For example, it was found that a certain dealer removed the handles from 6-gallon cans of imported olive oil and punctured the cans where the handles had been soldered, substituted other oil for the true olive oil contained, and resoldered the handles in their original position, leaving the cans intact to all outward appearance.

The special surveys, in addition to the routine work of inspecting olive oil, during the year resulted in a number of seizures and prosecutions.

Experimental work conducted this year has shown the unreliability of the critical temperature of dissolution and of the violet ray in detecting the presence of foreign oils in olive oil and the reliability of the iodine number in detecting the presence of cottonseed oil.

SHELLFISH

A resurvey of crab-meat packing establishments, an investigation of which in 1927 showed many objectionable features, indicated that the sanitary reforms suggested at that time had been very generally adopted, and that the pack as a whole is now being properly graded and correctly labeled. The attention of the packer concerned and of the State officials was called to certain practices which might lead to the shipment of an illegal product. Insanitary factory conditions are invariably controlled through cooperation with State authorities because of their greater power in the regulation of such matters.

STOCK FOODS

Each year brings a comparatively large number of illegal shipments of stock foods, little variation in the forms of adulteration and misbranding being evident. This year feeds low in protein and fat and high in fiber and moisture were found, as well as many short-weight lots. Action under the law was instituted to curb these frauds against the farmer, and many plants were visited with a view to checking faulty practices at their source.

VEGETABLES AND VEGETABLE PRODUCTS

The seasonal inspection of tomato-products canneries brought to light several new types of adulteration, notably the addition of thickening agents, such as gum. Catsup adulterated with

gums and artificially colored closely simulates a high-class product, and high-grade products were difficult to prepare from tomatoes of the 1928 crop.

A cooperative Federal and State inspection of tomato canneries stopped at the source the shipment of 75,000 cases of adulterated or misbranded pulp, puree, and catsup put out by 21 factories. Some of these products contained excessive rot, some contained undeclared color, and one contained added gum. Interstate shipments of other lots of goods similarly in violation were seized.

Upon the complaint of pimiento canners who do not use the oil process that the finished products of some of their competitors contained mineral oil, a special investigation of this feature of the process was made during the routine survey of pimiento canneries to check up on the net weight and quality of the product packed. A very small quantity of mineral oil was found in the oil-treated pimientos. Appropriate corrective measures were taken.

WATER

Analysis in 1927 of water from a West Virginia spring both before it was bottled at the spring and after it had been bottled and shipped in interstate commerce showed that it was polluted. Immediate steps were taken to remedy this serious situation, but the company shipping the water raised so many obstacles that no court decision in the matter was reached. A second survey, therefore, was conducted in 1928. Bacteriological examination of water at the source showed pollution. Attempts to collect samples from interstate shipments, however, were frustrated by the company. Accordingly, the cooperation of State officials was asked. As a result of the activities of these officials, samples were collected in Pennsylvania and analyzed. The results of analysis confirming the first results, seizure under the Federal food and drugs act was effected and the company's license to distribute mineral water under the Pennsylvania law was revoked by the State officials.

Nor did the case stop there. The West Virginia Department of Health, when informed of the findings in Pennsylvania, made a careful investigation of conditions at the spring. As this investigation also showed the pollution previously reported, the water company was warned to take immediate steps to adopt certain specific changes which would insure a safer water supply. Most of these recommendations were adopted.

IMPORTED FOODS AND DRUGS

The food and drugs act provides for the inspection of foods and drugs offered for entry into the United States. The invoices covering the shipments and sample cases are made available for inspection at the time they are being examined by appraisers of merchandise in accordance with the provisions of the tariff act. All invoices and shipments are inspected, but in general samples are taken only from lots that are suspected of being adulterated or misbranded. Although samples of every shipment of certain commodities are taken, the condition of others can be accurately determined by taking comparatively few samples, owing to past experience with the same products and to a knowledge of the practices of the shippers concerned. From time to time, however, each field is covered as fully as the limited personnel will permit.

The act provides that products offered for entry may be delivered to the importer under bond, pending results of examination, and provides for the exclusion of all adulterated or misbranded goods. A product that is misbranded, though not grossly, or adulterated, though not seriously, may often be brought into compliance with the law by relabeling or renovating. When this has been properly done and reinspection shows that the product meets the requirements of the law, the shipment may be released. This privilege of relabeling or renovating is not granted when the adulteration or misbranding is of a serious nature or when the shipper has been found guilty of repeated violations of the act.

Although a large number of imported foods and drugs have been examined during the fiscal year, with a corresponding number of detentions, comparatively little that requires special mention has developed.

As figs are subject to deterioration from attack by larvæ or mold, a thorough examination of all shipments offered for entry was made during the year. It led to the detention of a large number of shipments but somewhat less than the number detained during the fiscal year 1928, indicating some general improvement in the quality of imported figs.

One death and one serious illness resulted from the consumption of canned cippollini or shallots infected with

Bacillus botulinus that were imported from Italy and shipped to various parts of the country. As soon as the outbreak of botulism caused by eating these shallots was reported, immediate steps were taken to trace all lots and remove them from the market. With the cooperation of State and city officials this was done. Except for the prompt action of these officials, it is almost certain that many more fatalities would have resulted from the consumption of this product. Examination of the shipment showed that not more than half the cans in the entire consignment were sterile. It is quite clear that the batch was underprocessed. Although some of the cans in the lot showed evidence of marked swelling, others gave little or no evidence of decomposition. The material from the cans that apparently were not springers, as well as that from the swells, was toxic to experimental animals. Because of this outbreak, steps were taken at once to have nonacid canned goods offered for entry into this country thoroughly examined to make sure that they are sterile and, if not sterile, to determine the types of bacteria present, particularly with a view to determining whether or not they are likely to cause spoilage or are of the type that may develop dangerous toxins. In general, the condition of these canned products has been fairly good, with an undesirable degree of nonsterility in certain shipments or in the output of a few shippers. The presence of toxic organisms was proved in but one shipment, aside from the shallots.

The examination of a large number of shipments of coffee resulted in an unusually large number of detentions of shipments of low-grade coffee that failed to meet the department's requirements.

Most of the potent crude drugs mentioned in the United States Pharmacopœia and the National Formulary are of foreign origin. Examination of these crude drugs to make sure that they meet the requirements of the Pharmacopœia or the National Formulary is an important piece of work. Crude drugs that are required by the United States Pharmacopœia to meet a specific physiological assay have been subject to particularly careful scrutiny. For example, every shipment of ergot offered for entry during the fiscal year just ended has been fully examined and assayed to determine its potency and other factors. This crude drug has improved markedly in quality, and very few shipments of a product either deficient in potency or not in conformity with the general pharmacognostic description and tests laid down in the Pharmacopœia were found.

FOOD STANDARDS

The food standards committee, composed of nine members, three from the Food, Drug, and Insecticide Administration representing the Federal Government and six representing State food and drug departments, met twice during the year.

At the first meeting, in October, 1928, the proposed definition and standard for mayonnaise which had been the subject of a public hearing was further revised and adopted. The definition for meal as it refers to ground grain was amended and adopted. The committee also made revisions, which were approved, of the definitions for oil of cinnamon and oil of cassia and their extracts, and for ginger ale and sarsaparilla. Attention was given to definitions for jellies and preserves, for ice cream, and for whole-wheat flour, but definite conclusions on these topics were reserved. One informal hearing was granted to manufacturers on a proposal to define sauerkraut juice.

At the second meeting, held in April, 1929, the committee adopted proposed definitions for whole-wheat flour and for a so-called "bolted" or "scalped" graham flour or meal. These proposed definitions were subsequently released to the public for comment and criticism.

Two informal hearings were granted to food manufacturers, one group representing the manufacturers and bottlers of grape juice and grape beverages who desired definitions and standards for both the juice and the finished beverages. The second group requested that the present schedule of definitions for beverages and beverage flavors be extended and urged that immediate consideration be given to a number of specified flavors. The committee deferred until the next meeting further consideration of these schedules.

TEA ACT

The tea act, passed in 1897 and enforced by the Department of Agriculture since 1920, is designed to prevent the importation into the United States of any tea that fails to reach the standards of quality, purity, and fitness for consumption set by the Government.

The amount of tea imported into the United States during the fiscal year exceeded that imported during the previous fiscal year by 2,487,651 pounds. This increase was confined almost entirely to India, Japan, and China black teas, there being a marked decrease in importations of China green teas and Formosa oolong teas and a slight decrease in the importations from Ceylon and the Dutch East Indies. With the exception of China black teas, the kinds of tea being imported in larger quantities are those that are extensively advertised by the countries of production.

Of the 93,593,264 pounds of tea examined, 115,084 pounds, or 0.123 per cent, was rejected. Of this amount, 106,066 pounds was rejected because it was substandard in quality, while 9,018 pounds was rejected because it fell below the standard of purity. As was the case during the preceding fiscal year, the largest percentage of rejection was shown for Canton oolong, the variety consumed principally by the Chinese in the United States. Most of the other rejections for quality were due to damage or deterioration during transportation. The rejections for impurity were due to the fact that the teas showed an excess of extraneous matter over that contained in the standard, not because of the presence of artificial coloring or facing material, as was the case in most of the rejections for failure to meet the standards for purity made in past years.

Of the total quantity of tea rejected by the tea examiners, only 13 rejections, amounting to 31,160 pounds, were protested by the importers. The board of tea appeals sustained the findings of the examiners in 10 cases and sustained the examiners in about one-half of the teas involved in one rejection.

A comparison of the quantities of tea examined at the various tea-examining stations shows an increase in examinations at New York over those of the last fiscal year, with a proportionate falling off at Boston, while those at Seattle, San Francisco, and Honolulu remained about the same.

Fully fermented (black) teas continue to show an increase at the expense of green teas, the semifermented or oolong teas remaining about the same, with only a slight falling off.

An 838-pound shipment of tea that was grown and manufactured in the State of Oaxaca, Mexico, was imported. The grower stated that this tea was produced on a coffee plantation at very high elevation.

TABLE 3.—*Kinds and quantities of tea examined, passed, and rejected during the fiscal year ended June 30, 1929*

Variety	Quantity examined	Quantity passed	Quantity rejected—	
			For quality	For purity
	Pounds	*Pounds*	*Pounds*	*Pounds*
Formosa oolong	8,320,957	8,319,077	1,880	
Congo	2,988,333	2,957,212	31,121	
India	21,106,943	21,100,471	6,472	
Ceylon	26,390,621	26,377,876	12,745	
Blended Ceylon and India	875,083	875,083		
Java	7,394,940	7,383,794	11,146	
Sumatra	402,669	402,574	95	
Ceylon green	105,848	105,848		
Ping Suey green	5,094,694	5,081,246	5,510	7,938
Country green	492,803	492,803		
Japan	17,925,971	17,921,121	4,850	
Japan dust	1,468,731	1,468,731		
Capers	448	448		
Scented orange pekoe	21,025	21,025		
Scented Canton	451,075	447,499	3,576	
Canton oolong	355,470	326,057	28,333	1,080
Jasmine	61,500	61,162	338	
India green	122,146	122,146		
African	9,419	9,419		
Mexican	838	838		
Mixed origin	3,750	3,750		
Total	93,593,264	93,478,180	106,066	9,018

TABLE 4.—*Quantity of tea examined at ports during fiscal year ended June 30, 1929*

Port	Quantity examined	Quantity passed	Quantity rejected—	
			For quality	For purity
	Pounds	*Pounds*	*Pounds*	*Pounds*
Boston	17,808,835	17,806,355	2,480	
Honolulu	355,368	355,368		
Seattle	11,892,627	11,885,750	6,877	
New York	52,545,199	52,488,475	56,724	
San Francisco	10,991,235	10,942,232	39,985	9,018
Total	93,593,264	93,478,180	106,066	9,018

TABLE 5.—*Teas examined and rejected, 1915 to 1929*

Year	Quantity examined	Quantity rejected [1]	
	Pounds	*Pounds*	*Per cent*
1915	95,306,854	948,475	1.00
1916	109,536,526	1,768,573	1.61
1917	105,981,158	954,425	.90
1918	148,684,384	2,354,277	1.58
1919	113,338,535	1,420,568	1.25
1920	96,862,858	145,246	.15
1921	71,851,847	350,597	.49
1922	87,398,221	1,620,162	1.85
1923	96,267,920	277,104	.29
1924	104,492,743	63,159	.06
1925	92,925,470	84,137	.09
1926	98,551,814	457,537	.46
1927	97,595,579	100,708	.10
1928	91,105,613	57,121	.06
1929	93,593,264	115,084	.12

[1] The rejections made by the tea examiners, not the final rejections made by the United States Board of Tea Appeals.

IMPORT MILK ACT

The Federal import milk act, which became effective May 17, 1927, requires that foreign milk or cream offered for entry into the United States shall meet a definite standard of quality and guards the safety of such products from a health standpoint.

Practically all of the foreign milk and cream coming within the scope of the act is produced in Canada, although some small importations of Mexican origin enter southern California. The great bulk of the Canadian production comes from the Provinces of Quebec and Ontario and is entered at points in New York, Vermont, and New Hampshire. To supervise these importations and to inspect the producing dairies and plants, the administration established a principal laboratory at Rouses Point, N. Y., with sublaboratories at Richford and Newport, Vt. The detail of supervision falls into three groups—sampling and testing in connection with maintenance of bacterial standards and standards for temperature, and proper tagging of milk and cream at the time of importation; analytical work performed at the laboratories; sanitary inspection of dairy farms and shipping plants in Canada.

During the fiscal year there were collected in excess of 7,000 samples, representing more than 10,000 subdivisions. These consisted principally of raw milk, with pasteurized cream ranking next, and pasteurized milk and raw cream in this order of volume. Of the total number of samples collected and examined, more than 13 per cent were found to contain bacteria in excess of the limit permitted by the act. In consequence, the offending shippers were cited to hearings when the violation justified such procedure, and in some other cases in which the samples were of doubtful character, but not seriously in violation, the responsible shippers received letters of warning. In the case of shippers who could not institute necessary reforms and who were found to repeat former offenses, the initial action was followed by suspension of permit. Such action was taken against 195 shippers, of whom 87 were later reinstated upon satisfactory proof of compliance with the terms of the act.

Sanitary inspections were made of the dairy farms operated by small producers, as well as of the large plants or establishments collecting the output of many contributing dairy farms, and in addition inspections were made of those dairy farms not holding permits but contributing to the supply of the larger plants. Such inspections were made during every month of the year.

A total of 790 visits were made to the larger permit holders operating plants, and 758 inspections were made of dairy farms. Embargoes were placed on the product of 54 of these dairy farms, which restrictions were lifted later in the case of 27 of the farms where sanitary conditions had been so improved as to justify this course. There has been a marked improvement in the sanitary conditions at creameries and dairies during the fiscal year over those found to prevail during the preceding year. This is true not only of the larger plants and pasteurizing establishments but also of the small dairymen and farmers who do not always have at their command sufficient capital or the benefit of expert advice.

An immediate effect of the rigid application of the terms of the import milk act was to curtail the volume of importations. Although figures are not available for the entire year, it is safe to assume that more than 30,000 cans of milk or cream were excluded from entry for such infractions of the law as high bacteria content, high temperature, improper tagging, and production under insanitary conditions. Another effect of the enforcement of the act, although more indirect, was the exclusion of large quantities of milk and cream produced and handled by farmers and establishments which would not meet the demands of the act and were not able to qualify to the extent of obtaining a permit. Import statistics for the last 10 years show that there had been a steady increase of importations of Canadian-produced milk into the United States from 1919 to 1927, but these figures declined in 1928 and suffered a still greater decline in 1929. While all of this reduction in imports is not attributable to the requirements of the Federal import milk act, there is no doubt that this measure was directly responsible for some of the decrease.

The efforts of the administration's forces have been aided greatly by the splendid cooperation received from representatives of the Canadian Department of Agriculture and also from provincial creamery officials. The Canadian authorities made the initial physical examinations and tests of animals and sanitary inspection of plants or dairy farms operated by those applying for permits, as authorized by the terms of the act. In addition, they made many reinspections either of their own volition or with representatives of the administration, and their efforts were of material assistance in lessening the amount of work which would otherwise have devolved upon the administration.

INSECTICIDE ACT

The insecticide act, which became effective in 1910, is designed to prevent the sale of insecticides and fungicides that fall below the strength claimed for them, that will not accomplish the results promised for them, or that are injurious to plants.

The procedure for inspecting products under this act was modified during the latter part of the year to base regulatory operations primarily on information gained as a result of direct factory inspections. When necessary, this information has been supplemented by inspection and sampling of shipments of insecticides and fungicides found in the channels of trade. The adoption of the factory-inspection method for the investigation of insecticides and fungicides, an adaptation of a well-established and standardized plan that has been proved effective in the control of food and drug products, makes possible much more adequate control than is obtainable by a general checking of the many thousands of interstate shipments. The manufacturers of insecticides and fungicides, unaccustomed to the practice of factory inspection, at first showed a tendency against full cooperation with the administration's representatives. This attitude has been largely dispelled by correspondence and personal explanation of the plan by officials, however, and most manufacturers now recognize that factory inspections provide necessary information with the minimum of disturbance in the trade, add immeasurably to the effectiveness of regulatory operations, and make it possible to spend the time thus saved on manufacturers who are putting out illegal products to the disadvantage of both the public and ethical manufacturers.

ROUTINE INSPECTION

During the year, 1,384 samples of insecticide and fungicide products were taken. A general classification of the articles represented in the collection is given in Table 6.

TABLE 6.—*Insecticides and fungicides sampled during the fiscal year ended June 30, 1929*

Product	Number of samples
Arsenate of calcium and boll-weevil preparations	92
Arsenate of lead	164
Bordeaux mixture and combinations of Bordeaux mixture with insecticides	70
Chlorinated lime	17
Cyanide preparations	4
Dips for animals	33
Disinfectants, germicides, bactericides	110
Fly preparations for animals	20
Fish-oil and whale-oil preparations	8
Formaldehyde preparations	12
Insect preparations, household use	257
Miscellaneous insecticide and fungicide preparations, agricultural use	182
Lice and mite killers	70
Lime-sulphur solution and sulphur preparations	82
Nicotine preparations	31
Paris green	61
Pyrethrum and hellebore powders	31
Miscellaneous	140
Total	1,384

Of the 1,384 samples collected, 461 were samples of new products never before sampled. More than 500 of the samples collected were found to be in violation of the law in some respect. Appropriate corrective measures were instituted, including the reference of 51 cases for seizure or criminal prosecution.

These actions taken under the act were based on the chemical analysis of 943 samples of insecticides and fungicides, on the entomologists' reports on 1,001 samples, on the fungicidal tests of many samples, on veterinary reports on 641 samples, and on bacteriological examination of 149 samples of germicides and disinfectants.

During the year 29 consignments of insecticides and fungicides offered for importation into the United States were found not to comply with the provisions of the act, and it was recommended that they be refused entry until the labels had been corrected and that future shipments of the products be detained to determine their compliance with the law. The records reveal that most of the pyrethrum flowers offered for importation were of a good grade of closed flowers.

SPECIAL INVESTIGATIONS

In addition to the routine tests, much investigational work was done under the insecticide act.

CHEMICAL TESTS

Methods of analysis covering all classes of products being examined have been developed and sent out to the stations, to keep the field supplied with the latest methods. The investigation of fluorine compounds has progressed to the point where two articles, one dealing with the determination of total fluorine, the other with silicofluoride, are in the course of preparation for publication. A method for the direct electrolytic determination of copper in combinations of Bordeaux mixture and Paris green, without the previous removal of arsenic, was studied and presented at the last meeting of the Association of Official Agricultural Chemists.

Pyrethrum flowers were separated microanalytically into various portions, so that the location of the active principles may be determined by entomological and chemical tests. A compilation of the names of all plants of possible value as insecticides was undertaken jointly with the Bureau of Chemistry and Soils. The first part of the work is practically ready for publication under the title "Plants Reputed to have Insecticidal Value: 1. Plants Found in India."

ENTOMOLOGICAL TESTS

Special entomological investigations carried on in Washington dealt mainly with pyrethrum and its extracts, and included a study of flowers from various sources harvested at various degrees of maturity, to determine whether the differences in effectiveness commonly reputed to exist in these flowers are real or not. Toxicity tests and an analysis of the results from the viewpoint of the theory of probabilities have shown that the prevalent ideas of the superiority of flowers from certain sources, and of closed over open flowers, are not generally true. This work has been completed and will be published as soon as certain chemical work on the estimation of the active principle by newly published methods of analysis has been finished. Incidentally, a pronounced effect of the degree of illumination on the reaction of insects to pyrethrum powder was observed and its study undertaken.

In South Carolina the work on boll-weevil preparations continued from last year confirmed the findings of the previous season. In Florida a large

amount of experimental work was carried out on mosquito, chigger, and fly preventives and on fluosilicates and pyrethrum. Papers embodying the results of insecticidal tests on the oils and alkaloids of larkspur and staves-acre seeds and on the repellent action of paradichlorobenzene and naphthalene against the clothes moth larvæ were published.

FUNGICIDE TESTS

Comprehensive tests were made of the efficacy of the more important types of fungicides in controlling the principal plant diseases in localities where those diseases occur in epidemic form, and simultaneously the question of injury to the host plant received attention. The comparison between various dusts and liquid fungicides was continued. An investigation of the adhesiveness of Bordeaux mixture and various other copper fungicides has shown that commercial products used as dusts do not adhere as well as a properly prepared homemade product but they may do so when applied as sprays.

VETERINARY TESTS

Tests were made on animals with commercial preparations recommended for various external parasites, and the insecticidal value of pine oil and its effect on animals were investigated.

BACTERIOLOGICAL TESTS

Two hundred and sixty-six unofficial samples of germicides, antiseptics, and disinfectants were subjected to bacteriological examination.

The effect of storage on the chemical and antiseptic properties of silver protein solutions was studied chemically and bacteriologically, the results of the study being published in a scientific journal.

CAUSTIC POISON ACT

The caustic poison act, passed in 1927, applies to the following substances and preparations containing them in a concentration of the strength noted or stronger: Hydrochloric acid, 10 per cent; sulphuric acid, 10 per cent; nitric acid, 5 per cent; carbolic acid, 5 per cent; oxalic acid, 10 per cent; any salt of oxalic acid, 10 per cent; acetic acid, 20 per cent; hypochlorous acid or its salts (except chlorinated lime) to yield available chlorine, 10 per cent; potassium hydroxide, 10 per cent; sodium hydroxide, 10 per cent; silver nitrate, 5 per cent; ammonia water, 5 per cent. To acquaint the public with the harmful nature of the substances, and, as a consequence, cause the exercise of needful care in their use, particularly keeping them inaccessible to children, the law requires that the containers shall bear conspicuous and easily legible labels conveying the common name of the caustic or corrosive substance, the name and place of business of the manufacturer, packer, seller, or distributor, the word "poison" in letters of a certain size and style, and directions for treatment in case of accidental personal injury.

The survey of manufacturers of products coming within the scope of the law, which was begun last year with a view to bringing its provisions to their attention and initiating such action as might be necessary to see that legal labels were prepared and used, resulted in the inspection of over 900 establishments, 715 of which were engaged in interstate traffic or sale in the Territories or the District of Columbia. The officials of the administration in Washington and in the field, through correspondence and personal conferences, have reviewed thousands of labels, and have found that, with very few exceptions, manufacturers and distributors are desirous of having their products bear labels that comply exactly with the law. It has not yet been necessary to resort to court action, either by criminal prosecution or seizure of shipments.

A review of the factory-inspection data reveals that 15 concerns are engaged in the large-scale production of the sodium-hydroxide product known as lye, for marketing either under their own labels or under labels of several hundred wholesale and retail distributing firms. Other sodium-hydroxide products, such as drainpipe openers and toilet-bowl cleaners, were found to be marketed by 151 individuals or companies. Many of the labels on these articles required attention under both the caustic poison act and the insecticide act.

More work was necessary to bring the labels for ammonia water, a product marketed under a large variety of brand names, into compliance with the law than for any other substance covered by the caustic poison act. Factory reports on 287 manufacturers and distributors of this product were considered. A check of these reports shows 166 manufacturers of sulphuric acid, 132 of carbolic acid, 124 of oxalic acid, 93 of hydrochloric acid (muriatic

acid), 90 of acetic acid, 80 of nitric acid, 23 of potassium hydroxide, 21 of silver nitrate, 9 of hypochlorous acid, and 6 of salts of oxalic acid.

Attention was given also to labels for a large number of preparations containing the caustic or corrosive substances in the concentration cited in the act, such as indelible ink, toothache remedies, straw-hat cleaners, coal-tar dips and disinfectants containing phenol, metal polishes, deodorizers and cleansers, soda fire extinguishers, caustic pencils, paint and enamel removers, cleaners, and stain removers.

Most of the investigational work under the caustic poison act was with preparations containing carbolic acid, 146 samples of coal-tar dips, disinfectants, etc., being examined for their carbolic-acid content. As the published methods for the determination of carbolic acid are not applicable in the presence of methyl salicylate, a satisfactory method was developed for use in the presence of this substance. A description of it has been presented for publication in a scientific journal.

Work to determine the status of the United States Pharmacopœia product "aromatic sulphuric acid" under the caustic poison act showed that this preparation is anomalous in that when first made it contains enough free sulphuric acid to bring it within the provisions of the act but, with the lapse of time, undergoes chemical changes resulting in a decrease of free acid, so that after about two weeks it contains less than the proportion which requires labeling under the act. The results of this investigation have been presented for publication.

An investigation of the corrosive nature of sodium bisulphate and of its content of "unneutralized" sulphuric acid was also made.

NAVAL STORES ACT

The naval stores act, which became effective in 1923, is a dual-purpose act, having a service, as well as a regulatory, clause. It requires that all rosin and turpentine in interstate or foreign commerce shall be sold under standards established by the act and authorizes Government inspection of naval stores upon request.

TURPENTINE

Laboratory examination of samples of turpentine, as well as other thinners and substitutes for turpentine, formerly done in Washington was taken over by the districts during the year. The result of the work on these products indicates a very satisfactory improvement in their quality and a general observance of the requirements of the law governing the methods of selling them. Examination of 55 official samples of gum spirits of turpentine, 11 of steam-distilled wood turpentine, 1 of destructively distilled wood turpentine, and 13 of mineral-oil thinners and substitutes showed only 2 cases of actual adulteration. Steps were taken to correct these violations.

ROSIN

Sixty-eight lots of rosin, representing shipments of approximately 5,200 barrels, were sampled and graded at northern consuming points. Of these, 12 lots were found to be seriously misgraded, owing to the practice known as "charge grading," where grading is done on samples drawn from the vat or barrels immediately after the rosin has been drawn from the stills and while it is still hot and molten.

CONVICTION FOR MISGRADING

Two citations covering the sale of misgraded rosin were issued. A dealer who was violating the act by removing inspection and grade marks placed on rosin barrels by Government inspectors, substituting higher grade marks and exporting the rosin on the basis of the higher grade marks, was cited and prosecuted. A plea of nolo contendere was entered and a fine of $50 assessed by the court.

SERVICE

Under the service feature of the naval stores act, 172,604 barrels of rosin were classified and graded, 171,321 barrels for producers at the stills in the South and 1,283 barrels for distributors or consumers in the North and East. In all, 497 United States rosin classification and grade certificates covering this rosin were issued. Practically all rosin made in Texas, Louisiana, and Mississippi was Government inspected. At the opening of the 1929–30 naval-stores season in April, the administration, at the request of the producers, took over the inspection of rosin at a number of additional stills in Alabama and at several near Homerville, Ga., the first in the eastern section of the naval-stores belt to ask for this service.

Seventeen samples of turpentine and four samples of rosin were analyzed on request. Of these, six samples were officially taken and the results covered by turpentine classification and analysis certificates. The other

11 samples were not taken by representatives of the department, but were submitted by the dealer. Under these conditions only an analytical report, without certificate, could be given.

Total returns to the Treasury during the fiscal year under the service feature of the naval stores act amounted to $11,836.29, of which about $150 covered reimbursement to the Government for expenses incurred in connection with taking of samples for analysis and grading on request or in settling disputes between seller and buyer over the quality of goods delivered.

Analysis, classification, and grading of turpentine and rosin under the service feature of the naval stores act are available to all those interested, whether producers, dealers, or consumers. The administration maintains experienced rosin graders and classifiers at Washington, at the New York, Cincinnati, and Savannah stations, and also at Mobile, Ala., Gulfport, Miss., and De Ridder, La.

STANDARDS

The development of the recovery of turpentine vapors from the digesters in the cooking of resinous wood for paper pulp by the so-called "sulphate" process has continued during the year, calling for a new standard for this material, which is distinguished by a characteristic odor and other properties. Heretofore this product has been classed and sold as steam-distilled wood turpentine. In accordance with the authority granted by the naval stores act, a new standard, designated "sulphate wood turpentine," was promulgated by the Secretary of Agriculture on December 20, 1928, to take effect March 20, 1929. Under this definition, sulphate wood turpentine is wood turpentine obtained from wood by the sulphate process. No chemical properties have been specified or requirements set for this class of turpentine, as these are lacking in the official descriptions for the older well-known turpentines.

Two sets of rosin standards, assembled from nonfading colored glass, were assembled and deposited on loan with a large producer in Louisiana and a large consumer in Philadelphia. Such deposits are made on request, and their safety and care are secured by a $200 deposit with the department, to be returned when the standards are surrendered.

COLLABORATION WITH OTHER DEPARTMENTS

The administration collaborated with the Post Office Department, the Department of Justice, the Federal Trade Commission, and other branches of the Government, most of this work, as in the past, being done under the mail-order fraud law, enforced by the Post Office Department. Under this law 73 cases, calling for numerous analyses, reports, hearings, conferences, and appearances in court and before grand juries, were handled. Of these, 33 cases were closed, either on fraud order or affidavit. When a fraud order is issued all mail is marked fraudulent and returned to the sender. Other firms whose business was not in harmony with the law voluntarily discontinued the use of the mails for fraudulent purposes and gave affidavits to that effect. The cases in which fraud orders were issued involved obesity preparations, rejuvenation schemes, pyorrhea remedies, weight makers, rheumatism cures, asthma cures, cancer cures, tuberculosis remedies, heart-trouble preparations, hair growers, and treatments for paralysis and Bright's disease and other kidney ailments. Alcoholic purveyors in the guise of cures for various ailments claimed their share of attention. The cases discontinued on affidavit included a skin-disease treatment, an obesity treatment, a rejuvenation scheme, weight makers, pyorrhea cures, a cap device alleged to grow hair, and a supposedly electric belt and insoles for the treatment of rheumatism and kidney ailments.

The Federal penal code, forbidding fraudulent transactions through the mails, closely allied with the mail-order fraud law, is enforced by the Department of Justice. Prosecutions under this law are based in part on information furnished by the administration. In one case, brought against a tuberculosis treatment, the chief promoters have been indicted and are out on bonds of $10,000 each. In another, brought against a firm promoting a number of schemes, such as fat reducers and hair growers, a fine of $1,000 and a penitentiary sentence of 18 months were imposed. The trial of the vendor of a cure for any disease man is not born with resulted in a sentence of three years in the penitentiary and a fraud order against the business. The promoters of a height-increasing scheme have been indicted.

Poisons in the mails have received their usual consideration, a number of products, mostly candies, supposedly poisoned, being examined. In no case was poison found. A product containing chloral hydrate, another containing potassium chromate, and another hyoscyamus were denied the use of the mails.

Soap, hair dyes, obesity preparations, rejuvenation schemes, radiotized water claimed to be a cure for arthritis, to increase thyroid, adrenal, and other gland activity, to reduce fat and cause underweights to gain in flesh, and to make straight hair curly, a preparation supposed to remove dandruff, stop falling hair, grow new hair, and penetrate the hair follicles, and a bath salt advertised to bring to one's home the hygienic benefits of the expensive watering places of Europe were examined for the Federal Trade Commission.

A large number of samples of food were referred to the administration by other branches of the service to be examined for the purpose of ascertaining whether or not they complied with the specifications under which they were to be purchased and to see that deliveries made were in accordance with the contracts. Much work of this kind was done for the Veterans' Bureau, the General Supply Committee, the Federal Trade Commission, the Marine Corps, and the Department of Justice, to mention only a few of the 20 or more organizations for which such work was done.

Collaboration with the Federal Trade Commission in curbing false advertising of medicinal preparations is mentioned elsewhere in this report.

COOPERATION WITH STATE AND CITY OFFICIALS

The administration has continued its activities in the development and maintenance of cooperation with State health, food, and drug officials, both through its office of cooperation and through the representatives in the field. The customary personal contacts with officials have been supplemented by the attendance of representatives at meetings of both a national and a sectional character.

Strictly informal conferences, as represented by the periodical meetings at Philadelphia and Cincinnati, have continued, and the prospects are that other gatherings limited to 1-day conferences will be held at strategic points.

Instances have continued to multiply in which the prompt response to requests from the administration and judicious action on the part of State and city officials have facilitated the enforcement of the terms of the Federal food and drugs act to a degree which otherwise would have been impossible.

PUBLICATIONS

In addition to the annual report, three circulars and seven service and regulatory announcements, two of which are revisions, were printed. Five hundred notices of judgment under the food and drugs act and fifty under the insecticide act were issued. Five articles were contributed to the Yearbook of Agriculture, 1928, and 83 articles to scientific and trade journals.

U. S. GOVERNMENT PRINTING OFFICE: 1929

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REPORT OF THE FORESTER

United States Department of Agriculture,
Forest Service,
Washington, D. C., September 3, 1929.

Sir: I have the honor to transmit herewith the report of the Forest Service for the fiscal year ended June 30, 1929.

Respectfully,

Robert Y. Stuart,
Forester.

Hon. Arthur M. Hyde,
Secretary of Agriculture.

THE LUMBER INDUSTRY AND THE FORESTS

Twenty years ago the lumber industry of the United States was virtually at the peak of its expansion. Throughout the nineteenth century the output of the sawmills had risen uninterruptedly from decade to decade. As the century had advanced the rise had accelerated. It had far exceeded the growth in population. As against a consumption of 235 board feet per capita at the middle of the century, that at the close was 460 board feet. The total consumption at the middle of the century was less than 5,500,000,000 board feet; at the close, about 34,500,000,000. And the early years of the twentieth century carried the rise to still higher points.

The lumber cut in 1906 was estimated by the Forest Service as 46,000,000,000 board feet; the total consumption as a little over 44,800,000,000 feet; the per capita consumption 525 feet. That proved to be the turn of the tide, though it took another decade to establish the fact certainly. The sharp business crisis in the fall of 1907 naturally curtailed production in the following year; but both 1909 and 1910 showed a recovery, and 1912 nearly equaled the 1907 high mark. Not until 1915 did the lumber cut drop below 40,000,000,000 feet. Save in 1916, it has never since recrossed that line. In 1921 it fell below 27,000,000,000 feet. The latest year for which figures are available is 1927. The cut in that year was 34,532,000,000 board feet; the per capita consumption 280 feet.

An equally low per capita consumption has not been shown since 1859, except in the distress year 1921. The 1927 total cut substantially duplicated that at the close of the nineteenth century.

Twenty years ago the public attitude toward forestry, and toward the lumber industry, was largely shaped by two conceptions—that the country's timber supplies were diminishing so rapidly as to make certain an acute shortage before another generation would arrive on the scene, and that a monopolistic control of the remaining virgin timber threatened. Predictions based on the best data available at the time were freely made that if use continued at the then current rate the supplies of saw timber would be exhausted in from 20 to 30 years. It was, of course, not supposed that use would actually continue at an even pace as the forests shrank away—still less that use would continue to grow as it had been growing throughout the previous century of developing industrialism. But it was confidently held that the consequences of timber depletion were presently to become manifest in advancing lumber prices, enforced curtailment of consumption, declining lumber output, markedly enhanced stumpage values,

large speculative gains for timber holders, and widespread public inconvenience and hardship through an increasing shortage of forest products. Further, it was believed that the whip hand soon to be given the lumberman over the consumer by the establishment of a seller's market and by the ownership of a restricted and waning supply of an essential raw material was in imminent danger of gaining new power through the setting up of an artificial control of the market, with a view to further restricting output, raising prices, and increasing profits.

The downward trend of lumber production and consumption since 1907 falls in with the anticipations of that period. Nor is there lacking other evidence to support the view that the country has been steadily advancing toward a time of timber shortage, at least in the matter of saw logs. Many wood-using industries have found it increasingly difficult to obtain the kind and quality of raw material needed to meet their special requirements, or have been made uneasy by uncertainties regarding continued supplies and reasonable price levels. Many of the large-scale lumber operators in the eastern half of the country, and notably in the southern pine belt, have exhausted their stumpage and closed down. The area of cut-over lands on which little or no regrowth of valuable species is taking place and which are not in demand for any other purpose than timber growing continues to enlarge alarmingly. Millions of acres of timberland are cut over annually, with the practical certainty that a large part of the land will eventually come back on the public through tax forfeiture and with the creation of very serious local problems due to the withdrawal of industries, population, capital, and taxable values as the timber gives out. And, finally, there is the certainty that in spite of the decline in lumber production that has taken place in the last two decades, forest depletion is increasing.

In 1920 the Forest Service was called upon by a Senate resolution to report on forest depletion. The report showed an annual drain upon the forests four times the estimated current rate of growth. Of saw timber the utilization and destruction by fire and other agencies was put at more than five and one-half times the growth, and of softwood saw timber at more than six and one-half times. There were then many indications of an approach to true famine conditions. Spectacular price advances for lumber, newsprint, and other forest products were accompanied by acute shortages in the supply of many classes of material and by the inability of some industries to meet their requirements for high-grade material at any price. The report recognized that a combination of special and temporary factors was in considerable measure responsible for the extreme conditions then manifest, and it expressly disclaimed for forest depletion a more prominent rôle than that of an important contributing cause. In the light of what has transpired since, however, some of the conclusions then drawn need to be corrected. The predicted timber famine that gave rise to so much concern 20 years ago has not arrived.

Of this, conditions within the lumber industry afford fairly conclusive proof. It has not waxed fat on the expanding profits of a cornered timber supply. It wears none of the aspects of the trust octopus so vividly pictured in former days. It is not overprosperous. Neither through the building up of concentrated ownership of a dominating portion of the remaining timber supply nor through restricted production has anything to inspire fear of a controlled market come into sight. On the contrary, keenly competitive conditions have resulted in a chronic market instability, low profits as a rule, and often in production at an actual loss. The "lumber baron" has ceased to figure much in the popular imagination; his supposed economic power has proved more shadow than substance. The plain fact of the matter is that the lumber industry of the country, taken as a whole, would quite thankfully increase its output in a very substantial amount, if it could find purchasers willing to take the product off its hands at a reasonably remunerative price. In spite of the great industrial activity of recent years the lumber market has been much more of a buyer's than a seller's market. Not a timber famine, but a pressure to liquidate timber holdings that creates chronic overproduction, is the outstanding feature of the present situation as seen from within the lumber industry.

Last winter the board of directors of the National Lumber Manufacturers' Association formally asked that any legislation enacted to permit controlled production of oil or coal be made applicable to lumber. The objects of control would be price stabilization and conservation of the present stand of timber through the limitation of

output. Thus, it was thought, a condition of industrial equilibrium might be established, with more orderly marketing, less waste of material in utilization, longer duration of the present supplies of privately owned timber, better prospects for reforestation, and a smoother transition from dependence primarily upon diminishing stores of virgin timber to dependence upon growing forests.

There are both obvious similarities and obvious differences between the present situation of the oil industry and of the lumber industry. In each case conditions which seem impossible of control by the industry without the aid of public authority are forcing overproduction. In each case waste of an irreplaceable natural resource is involved—for virgin timber is practically irreplaceable because of the length of time necessary to grow material of the highest quality. In both cases overproduction is due to the fact that these irreplaceable natural resources are temporarily in too abundant supply to permit the establishment of a rational equilbrium between current production and consumption, and between present and future needs. In the case of oil this temporary superabundance of supply is chiefly due to the rush to find oil and get it out of the ground before some one else acquires it; in the case of timber, primarily to the financial pressure of carrying charges.

The known oil supplies if not supplemented by new discoveries will be exhausted much more quickly than will the virgin timber, at the present rate of use. With oil, however, there is the possibility of indefinite extension of the supply from fields not now known to exist, to say nothing of what can be obtained from the oil shales, and what may be produced from coal. Offsetting this in the case of lumber is the fact that new supplies can be grown. And in addition there is the competition of substitutes, which to a far greater extent with lumber than with oil are disputing its superiority and are ready to take its place as depletion enhances its price.

Lumber has to contend with many and varied substitutes. One of the reasons for the declining per capita consumption of lumber during the last 20 years has been that people have chosen to use other things. In part this has been because of changing conditions. Enlargement of transportation facilities has been obtained not by extensive railroad building, which requires much lumber, but by multiplying the mileage of improved highways. Rural requirements for new construction have diminished as the expansion of settlement has slowed down, while urban growth, engineering progress, increasing wealth, and new modes of life have combined to enlarge the relative consumption of brick, stone, steel, cement, and many other classes of material that compete with wood. With the depletion of local and regional timber supplies and the consequent inevitable increase in the cost of lumber due to remoteness, more expensive logging, or poorer stands, lumber has been handicapped in its struggle to hold its place and to obtain its share of the new business created by expanding population and industrial activity. It has also had to meet the competition of products made from wood fiber.

Undoubtedly as the supplies of virgin timber become further depleted this latter competition will increase. Research and invention will bring to light new ways of utilizing low-grade material. How extensive our future requirements will be for the kinds of products that in the past the lumber industry has derived from our vast virgin forests it would be rash to predict on the basis of present conditions and present knowledge. Perhaps about all that can be said with entire confidence is that the intrinsic qualities of wood, its relatively low cost of production, and the enormous land area available for growing wood assure it a leading place as a basic raw material for consumption in one form or another. In the same way, of course, it would be unsafe to predict on the basis of present conditions the character and extent of our future requirements for oil or coal.

From the standpoint of the public, two outstanding things are wrong in the lumber industry. High-quality raw material from virgin forests centuries old is being feverishly driven through the sawmills and pressed upon the market, with a large amount of waste of the lower-grade material in the processes of production and with a further waste of the product through its consumption for purposes for which less valuable material would have answered every essential need. In other words, though our original virgin timber is mostly gone, economic conditions have not reached the point at which the remaining stands are being sufficiently husbanded, with due regard to their unique quality and to future requirements. Beyond this, the

pressure to liquidate holdings of virgin timber is operating as a powerful deterrent to the reorganization of our forest economy on the basis of timber growing in place of forest exploitation, and to more rapid progress in establishing right methods of land use.

A single forest region—the Pacific Northwest—is preeminently characterized by the pressure to liquidate. The enormous stores of virgin timber provided in the forests of Washington and Oregon were for a long time grossly underestimated. Even now it is impossible, unfortunately, to give figures that can be regarded as more than rather rough approximations, for no true inventory of our forest resources has ever been obtained, though it is urgently needed. Probably, however, there is still in Washington and Oregon something like 600,000,000,000 board feet of saw timber. Supplementary to this stand as a means of meeting national requirements are another 275,000,000,000 feet in California, and also the heavy forests of northern Idaho and western Montana—to say nothing of the forests north of Washington in British Columbia, from which considerable imports have come into the United States, and our own supplies on the Alaskan coast.

All told, California, Oregon, Washington, Idaho, and Montana have stands estimated to approximate 1,000,000,000,000 board feet, of which somewhat more than half is privately owned. The lumber output of these five States is now about 15,000,000,000 board feet annually. On their face, these figures would seem to show that, even with no allowance for regrowth, cutting can be continued for a good many years at the present rate, or indeed at an increased rate, before the effects would be felt much.

But the ratio of the total estimated stand to current consumption is not the real heart of the matter. Far more important than the aggregate amount of timber is the question of its relative accessibility, on which depends its marketability. Lumbering began in the Pacific Northwest at the very water's edge. With prodigiously heavy stands of timber of the finest quality on land of gentle contours near tidewater, logging and local transportation costs were at a minimum. Naturally, the most accessible timber was the first to pass from public into private ownership, and the first to go to the sawmills. Because of its abundance, stumpage was of low value, and because of its remoteness from great consuming centers the market for its manufactured product was limited. Not until the early years of the twentieth century did western Oregon and Washington begin to send lumber in quantity east of the Rocky Mountain States.

As the industry grew it exhausted the stands of greatest accessibility and had to go farther back for its logs. Distance and rougher topography combined to increase the costs of operation and transportation. Railroad construction opened up new territory for the lumbermen and there was no lack of stumpage, still low priced—but it was stumpage that earlier had had only a speculative value or none at all. And this process of pushing farther and farther back from the water and into and up the mountains, where stands are poorer and logging more and more difficult, is still going on. In fact, it is still at a relatively early stage. The most inaccessible stands, that will be most expensive to log and will yield least, are still remote.

In anticipation of the time when the timber would be in demand, enormous quantities were speculatively acquired from the United States through use or misuse of the general land laws. Had it not been for the creation of the national forests, the acquisitions would have been still more extensive. The requirements of the lumber industry, however, have not equaled expectations, so that for the last 15 or 20 years there has been an overload of stumpage seeking a market, largely to escape the pressure of the carrying charges due to taxes, protection costs, and often interest on indebtedness.

The pressure to liquidate has resulted in plant expansion and has created a condition of market instability and chronic price depression often approaching demoralization. Any improvement in the demand for lumber is the signal for increased production. The result is that the last great reservoir of virgin timber in the United States is being depleted under conditions that involve deplorable wastes of raw material and at a more accelerated rate than is in the best public interest—though it has not gone far enough to restore the balance or fast enough to meet the wishes of distressed timber owners—while also acting as a deterrent to the process of readjustment of the lumber industry elsewhere throughout the country to a timber-growing basis.

THE EFFECTS OF PACIFIC COAST COMPETITION FOR LUMBER DISPOSAL

One of the evidences of the key position of the far-western forests in the national situation is the volume of Pacific coast lumber moving eastward via the Panama Canal. Prior to 1921 the shipments were relatively insignificant in quantity, never having exceeded 10,000,000 board feet except in 1914 and 1915. Between 1921 and 1926 they rose steadily from an initial 207,029,000 feet to a peak of 1,988,912,000 feet, and have remained since 1926 at over 1,900,000,000 feet. The bulk of the supply has come from Washington, in whose mills 72 per cent of the 1928 shipment of 1,964,221,000 board feet (including nearly 300,000 feet from British Columbia) was sawed.

Approximately two-fifths of the 1928 shipments entered the port of New York; and by far the leading wood has been Douglas fir. Between Douglas fir and southern pine a sharp competitive struggle has gone on in the New York and other eastern markets during the last few years. Prices have been unstable to a degree that has tended to dislocate the distributive mechanism and interfere with orderly marketing. Undoubtedly but for the fir cargoes, the closing down of many of the large southern mills that has been taking place as their supplies of stumpage have failed and the fast-approaching exhaustion of the virgin stands of softwoods in the South would have been reflected in quite different market conditions.

Together, the cut of these two leading softwoods, southern pine and Douglas fir, formed, in 1928, 70 per cent of the total softwood cut of the United States, and 56 per cent of the cut of softwoods and hardwoods combined. The cut of southern pine in the last six years has averaged approximately 12,000,000,000 board feet per year; of Douglas fir, 8,250,000,000 board feet. In 1923 Douglas fir made up 39 per cent of their combined cut; in 1928, 44 per cent. Their average prices at the mill by years, as compiled by the Forest Service, have dropped from $28.93 per thousand feet for Douglas fir and $30.81 for southern pine in 1923 to $20.01 for Douglas fir and $25.32 for southern pine in 1928.

In brief, the main competitive influence upon softwood lumber prices originating within the lumber industry is the regional competition between the Pacific Northwest and the South. There are, of course, large portions of the country in which one or the other of these producing regions occupies the field without competition from the other; there is, of course, competition potential or actual nearly everywhere from other softwood-producing regions; there is some competition from abroad; and there is always the competition with lumber of its various substitutes. Nevertheless, the general level of softwood lumber prices in the United States is determined primarily by the struggle between these two great sources of supply to dispose of their respective outputs.

Such conditions, of course, confer certain advantages on the consumer—though less, after all, than might be supposed. For if wholesale prices may drop sharply at any time because of a temporary oversupply of lumber, the dealer fears to carry normal inventories; and elements of uncertainty are introduced that tend to disrupt distribution as well as to create speculative risks. From these conditions nobody in the long run benefits. It is at least debatable if the ultimate consumer's interest has gained more than it has suffered in consequence of eastern lumber market instability and the resulting disturbance of the distributive service, with price flunctations that presumably have seldom been passed far enough down the line to lower by very much what the consumer has had to pay.

In preventing the consequences of southern forest depletion from becoming more marked, the advent of west-coast lumber in quantity upon the eastern market has simply repeated the history of each successive regional depletion in the past. When the virgin forests of the Northeast began to fail, the Lake States timber prevented the development of a condition of acute scarcity; and when the Lake States forests dwindled southern pine came into its own. Each of the great forest regions has been like a vast reservoir, ready to be tapped when its turn came. The barrier that has in each case held back the timber from coming on the national market ahead of its turn has been the cost of transportation. The longer the haul to the central markets, the higher the price that those markets must be ready to pay in order to make a new source of supply available. The Panama Canal, however, largely offsets the effect of the long haul from the Pacific coast. Lumber moving via the canal from Puget Sound to New York has been paying in recent months a freight charge ranging from $12.50 to $14 per thousand. The freight rate on lumber shipped

from Hattiesburg, Miss., to New York is approximately $11.60 per thousand.

The pressure to produce and market western lumber causes waste of the virgin timber in spite of the fact that the industry itself is keenly interested in lessening waste wherever this is practicable. The lumberman does not willingly leave in the woods or send to the burner material which if manufactured would give him even a small margin of profit. On the contrary, often he takes material that costs him more than he can get back. The industry is seeking efficiency along the same lines as other industries. It has lowered production costs through improved machinery and other methods of saving labor and increasing its percentage of utilization. As time goes on, more and more of the tree will be converted into industrial products. In short, the cause of the present waste of virgin timber is not to be found in the attitude of the lumbermen, who would gladly utilize more closely if they could, but in certain economic maladjustments that the lumber industry can not alter.

In the light of the event it is plain that a great economic mistake was made when the private acquisition of so much of the standing timber in the far West was facilitated, under a public policy of disposal. The too tardy creation of the national forests has mitigated but could not avert the disastrous consequences of passing into private hands so large a portion of the public timberlands, so long before the needs of the country would call for their productive utilization. The public concern in the matter, of course, relates not to the difficulties in which timber owners find themselves because they acquired more stumpage than they can carry, or misjudged the future market; nor primarily to extending a special form of governmental assistance to a particular industry in order to enable it to solve its own individual problems; but to the effect upon the general welfare of a fundamentally unsound economic situation. It is of much more concern to the public to get rid of conditions that handicap the forest owners in the Northeast, the South, or the Lake States who want to use their land to grow timber crops than it is to enable Pacific coast lumber companies to liquidate with a profit. It is of much more public concern to prevent forest destruction and forest land denudation and abandonment in the far West, with the depressing community effects that follow the wind-up of local forest industries, than it is to stabilize the eastern and national lumber markets as such. And this is true notwithstanding the fact that orderly marketing of any essential commodity and sound and prosperous conditions in all industries are matters of public as well as private solicitude.

By and large, the lumber industry must work out its own internal problems—and they are both large and difficult. It is already applying itself to the task. What will eventually have to be worked out is not merely greater industrial efficiency but the making over of the industry from one unrelated to and unconcerned with forest production to one correlated with and based upon the use of land for sustained, permanent supplies of whatever quantities and kinds of raw material the industry can profitably turn into marketable manufactured products; from a migratory and transitory into a fixed and permanent industry. And this is more than an internal problem of the lumber industry. It is also a public end—the attainment of a sound forest economy.

The greatest weakness of the industry at the present time is due to the fact that it owns an enormous area of forest land acquired not as land but as forest, is burdened, where it has not liquidated most of its stumpage, with very heavy investments in raw material that must be carried for years before it can be put to use, and has a set-up based solely on the manufacture of this raw material as rapidly as may be. As a manufacturing industry it is embarrassed by the extent to which its capital is tied up in timber and its profits are dependent upon the way this part of its investment works out. As an extensive owner of land it is embarrassed by the fact that its land ownership is auxiliary to a manufacturing interest entirely unrelated to the land as a productive resource and uninterested in its future, but with purposes of its own that, when carried out, sacrifice the land values for the sake of manufacturing profits.

The embarrassing feature in this case arises chiefly from the fact that the profits accrue to the enterprise,

but the sacrifice is inflicted upon the public, which is made poorer by the lowered productive value of the land. Thus the industry is confronted with an awkward question. Having acquired land in order to have timber for use in its own way and for its own purposes, to what extent may it have acquired along with the land a moral responsibility or public obligation in connection with its use? It is to the credit of the industry that it is putting this question to itself.

The immediate effect is to add to the embarrassments under which the industry labors in consequence of its own internal problems. The ultimate effect should be to hasten the adjustment which must be made anyhow before the internal problems of the industry will be entirely solved. The present adjustment of the industry to the forest is essentially a maladjustment. Without implication of censure, it may fairly be called an anachronism. To the extent that our forest economy is still based upon the lumbering of virgin stands with disregard for the preservation of forest productivity and the future of the land, it is a holdover from the past rather than a shaping of present methods to square with approaching conditions.

In the eastern half of the country, where originally three-fourths of the virgin timber grew and where to-day three-fourths of all the lumber produced in the United States is consumed, depletion has gone so far that but for the remaining western supplies our forest economy would be based primarily on the cutting of second growth. For the hardwoods, indeed, and for a large part of the wood consumption for local purposes, second growth is already in a dominating position. As that comes about, a profoundly altered situation is created. High-grade material previously held essential for many industrial purposes either ceases to be procurable at all or becomes so scarce and so expensive that radical readjustments of consumption are forced. Ingenuity in devising new ways of meeting industrial needs is stimulated to a degree that substantially lessens the hardships and burdens imposed on industry and the public. At the cost of many dislocations and a considerable net loss, consumption is in part readjusted to what the second-growth forests contain, in part to the substitution of other material for wood.

Inevitably a stable relationship of the forest industries to the forest land will in time be worked out. The forest owner will know what to grow, to whom he can expect to sell, and what prices for his output he can reasonably look for. But the process of readjustment to a forest economy based on timber growing should, if possible, be facilitated by a constructive public policy with respect to the far-western situation. Its formulation is not a task for foresters alone. It will call for the participation of financiers, economists, and leaders in the field of governmental and business relationships. For it is a question of devising some plan of action that will substitute orderly marketing for the present pressure to liquidate, without creating a monopolistic control of lumber prices by private interests or transcending the limits of sound public policy.

Failing the discovery and successful adoption of such a plan, economic forces acting within the limitations set by existing laws will have to work the matter out blindly and without regard to the public interests that are jeopardized. Forced liquidation, with its inevitable waste of the timber resource and postponement of the transition to a sound national forest economy, will gradually reduce the overload. As the more accessible stumpage melts away increasing costs of production and transportation will tend to raise the minimum price levels at which the western lumber can be placed on the eastern markets. Long before the last great reservoir of virgin timber is drained it will have ceased to interfere with the transition of the East from dependence primarily upon our original forests to dependence primarily upon new growth. It is quite probable that another decade will bring pretty nearly to an end the period of acute pressure to liquidate, which at the present time makes impossible faster progress toward the establishment of an equilibrium between supplies and consumption and the attainment of a sound forest economy. But the loss of even a decade in applying forestry to the land, which should have begun long ago to grow the new crops that will be badly needed long before they are ready to harvest, is a loss that the country can ill afford to suffer.

FORESTS AND LAND USE

Until relatively recently the aspect of our national problem of forestry which has chiefly engaged public attention has been the need to provide against a future shortage of timber; and in popular discussion the depletion and approaching exhaustion of our forest supplies still serve as the commonest argument for seeking to extend the practice of forestry. While it is entirely true and worthy of emphasis that our future requirements for wood make reforestation and the prevention of forest destruction a matter of large public importance, of still more immediate and tangible concern at the present time is the menace of nonproducing land and the destruction of land values for permanent productive use.

Perception of this menace is growing locally, through actual experience of the economic and social burdens imposed as denuded forest land ceases to be worth paying taxes on, or as attempts to cultivate it establish its essentially submarginal character for agriculture, or as the blight of impoverishment spreads sectionally through the loss of forest resources and the migration of forest industries. This is giving a new impulse to the movement for public forestry. It is particularly effective because it is originated not through the anticipation of a future general evil, but through the sharp sense of a present local one. It is beginning to exert a powerful influence for enlarged State policies of forestry, and to a considerable extent for an enlarged program of Federal land acquisition and national forest administration.

The latter is discussed farther on in this report. It may be mentioned here, however, that in addition to the demand for more purchases of land for national forests in the East, there is in two of the far Western States a growing perception of the danger of extensive tax delinquency and land abandonment following lumber operations, and a definite desire for national forest extension to bring cut-over lands under Federal administration as a means of preserving their productivity.

On the whole, the Lake States include the region in which the accumulation of cut-over waste lands has made most impression on the public mind and has called forth the most definite reaction in favor of remedial measures. The northern two-thirds of the States of Michigan, Wisconsin, and Minnesota formed the original Lake States pineries. During the past century the region supplied a cut of over 300,000,000-000 feet of softwoods, chiefly pine. At nineteenth century, the cut of Lake its peak, in the closing decade of the States pine was approximately 6,000,-000,000 feet annually. In 1927 it was less than 450,000,000 feet—a loss of about 85 per cent of the cut in 30 years. Only scattered remnants of the original forest growth remain, and the estimated area of merchantable second-growth is less than 14,000,000 acres out of a total land area for the three States of nearly 124,000,000 acres.

The southern third of the Lake States, originally occupied by hardwoods, with some prairie that in the extreme western part of Minnesota extended northward to the Canadian line, has been turned into prosperous agricultural country, but the great bulk of the pine region has proved unsuited to agriculture. Many settlers have tried in vain to make a living on these lands. On the occasional areas of better soils, however, agriculture may succeed. Since the amount of farm land on which a decent living can be made is too small to supply by itself an adequate basis for the support of local government, the maintenance of roads and schools, and the railroad traffic necessary to adequate rail transportation facilities, the waning of the timber and the disappearance of the forest industries have brought economic retrogression, railroad abandonment, mounting tax burdens, depopulation, and in some cases county bankruptcy.

About 20,000,000 acres in the Lake States pine region is land which though better suited to forest production than to any other purpose has been so nearly reduced to unproductiveness that much, if not most, of it will have to be reclaimed through artificial reforestation; and unless fire protection is systematically maintained throughout the region the amount of denuded and worthless land will grow. Tax delinquency is very extensive, with the prospect of eventual enforced public ownership of a substantial percentage of the land, via tax forfeiture.

In Wisconsin alone over 2,500,000 acres of land in the 17 northern counties were represented in the tax certificates offered for sale in the single

year 1927, and more than 4,250,000 acres in these counties had been tax delinquent one or more times previous to that year. In Minnesota the State Reforestation Commission report of last November stated that the amount of tax delinquency in the forest area is steadily rising and in one or two counties includes over half the taxable land area, and that the situation has resulted in confiscatory tax rates. In Michigan the State Conservation Commission reported under its jurisdiction at the close of 1928 approximately 1,500,000 acres of "tax homestead" lands, and in the same report the State forester declared 15,000,000 acres to be a conservative estimate of the total amount of "just such land as has reverted to the State."

All three States are awakening to the urgency of the land use problem created by forest destruction, are seeking suitable remedial measures, and are coming to recognize that a very large task of public-land ownership and administration with a view to restoring productivity through reforestation will have to be assumed, in addition to the finding of means for bringing about forest management by private owners. In New York likewise there is a new movement for the enlargement of public ownership and reforestation to meet the idle-lands evil, primarily arising in that State from the abandonment of farming on submarginal agricultural lands. Every considerable section of the East in which farms have been created by clearing presents the same sort of problems that the Lake States and New York are having to face. Further, in a majority of the Eastern States there is interwoven the problem of erosion and of flood control. In short, the question of right land use, vital alike to rural welfare and to sound national development, ramifies into many fields and wears many aspects, yet calls for a comprehensive, not a piecemeal, answer.

Agriculture and forestry together must supply the answer, and must work together to find it. Submarginal agricultural lands must be distinguished from those worth cultivating, and an effort made to find ways of guiding and assisting both agricultural development and ownership for forest use along lines that will best serve the public welfare. The right outcome will be attained when there has been brought about such an adjustment of agriculture to forestry, of forestry to agriculture, and of both to the soil resource as will enable the land to contribute to the most favorable economic and social conditions of rural life.

The reverse is happening now, on a tremendous and appalling scale. The extent of the losses which the Nation is suffering through the erosion of lands that are under cultivation is just beginning to be perceived. Erosion and its consequences in the form of altered stream-flow conditions and silt discharges impose larger public obligations than have as yet been recognized for the regulation of forest use in a large part of the East, and of range use in the West. To make regulation effective where the protective function of the forest is important, public ownership will have to be greatly extended. The program that will ultimately have to be formulated for this purpose, and that doubtless will ultimately be accomplished by a combination of Federal and State effort, can not be known without extensive and detailed study of the whole problem of erosion and flood control. In every direction, indeed, research is fundamental to the working out of a sound system of forest land use. But nowhere is there more urgent need to bring into play new forces for reversing present trends in the forest situation than can be found in much of the southern pine country.

For various reasons, tax delinquency has not as yet become conspicuous in the South as the aftermath of forest destruction. For one reason, the main development of lumbering in the "piney woods" followed that in the Lake States, so that there has not been time enough for the full force of the economic consequences to be felt. A great deal of the southern pine land still has considerable merchantable timber on it, partly as a result of regrowth, partly because more or less timber was left at the time of the original cutting. Some lumbermen who bought land in order to cut the timber off it believe that they can dispose of the land sooner or later for agricultural purposes; some, that it has value for grazing, or may be underlain by valuable minerals of one kind or another; some, of course, see that they can cut more timber from the land; while some hold

simply on the general principle that land is always worth something and will eventually have a market.

A few owners have in recent years become converts to the idea that timber growing should pay, and are planning to use the land for this purpose. A much larger number are farmers or estate owners, with every expectation of continued proprietorship. Thus a good share of the land is in stable ownership. In general, the percentage held by owners whose attitude toward the land is essentially speculative, as contrasted with those whose purpose is to keep and make use of the land, is lowest in the more easterly part of the southern pine belt and rises in the Gulf States with progress westward. A high degree of instability of ownership is found west of the Alabama River.

With the virgin stands of timber nearly gone, the tendency is to return to the lands already lumbered for whatever was left at the time of the first cutting or has come up as second growth. Saw logs from single trees scattered here and there over a large area can be profitably picked up and transported by motor truck 20 or 30 miles to a mill; portable sawmills seek out patches of young timber; and the market for poles and fence posts affords another opportunity to obtain from the land a little current return with which at least to pay taxes. Thus it is possible to carry the land until the last vestiges of the forest vanish through the removal of all the trees that might, if left, mature and scatter seed, and through unchecked ground fires that wipe out all the established reproduction. The financial requirements of the States and local communities make probable higher rather than lower land taxes. Many millions of acres in the South have reached a degree of denudation that virtually precludes any hope of their restoration to productiveness as a private undertaking and apparently insures their eventual abandonment to the public through tax forfeiture. In much of the southern pine region the history of the Lake States pine region will be repeated.

It is true that this is only part of the picture. Much of the South holds out a bright prospect for extensive private timber growing; the States are making rapid progress in fire protection and in building up capable forestry departments; and the interest of landowners in the possibilities of reforestation is becoming fairly widespread. Nevertheless, the fact needs to be faced squarely that not nearly enough is being done, and that at the very best a gigantic task of forest reclamation is going to be forced upon the public as the only alternative to permanent land unproductiveness on a major scale. Whether even the public can afford to reforest all the southern forest land that has been or will be denuded and that private owners will not wish to carry is a question.

Whatever is done will, to a large extent, have to be done locally, through State and county action. While the Federal Government has inaugurated land purchases for the establishment of a number of small forests scattered through the southern pine region, these are primarily for demonstration purposes. How much more than this, if any more, the Federal authority should undertake can be determined only after the whole situation has been studied further, trends have been observed, the workings of other remedies have been taken account of, and, above all, local realization of the needs has been fully developed and local efforts to meet them have been made.

The most urgent immediate needs are better knowledge as to the facts and greater effort to bring about the use of land for timber growing as a private enterprise. The States should recognize the problem that lies ahead of them, as the Lake States have done, and should seek through such means as commissions of inquiry, land economic surveys, and the like, to analyze it and formulate a forward-looking course of action. State forestry departments should be given greater scope and greater support; protection of forest lands against fire, the greatest of all causes of denudation, should be extended; and State policies of taxation should be overhauled and adjusted so far as possible to the necessity for preventing large amounts of land from becoming a public liability through loss of its productiveness. The whole situation will have to be worked out gradually, through experience and through research.

The latter is fundamental to any satisfactory progress. It is needed as a means of determining the basic economic facts that must be understood before sound public policies can be elaborated or private policies of land

use safely embarked upon, and it is needed in order to develop the best technical practices of timber growing and forest utilization. In the field of research lies one of the greatest opportunities for helpful Federal action. Both the importance of the forest resource and the public dangers that its destruction involves make increased effort in this field not merely desirable but almost imperative.

PROGRESS IN STATE FORESTRY LEGISLATION DURING THE YEAR

The form of the State organization for forestry work was modified in Nebraska by consolidating this work with the administration of State parks, game, and fish under a single board, and in West Virginia by setting up a chief forester in the department of game, fish, and forestry (renamed from the old game and fish commission).

Considerable legislation was enacted looking to enlarged policies of State forests. New York amended the conservation law to permit the purchase and development of State forests outside the "preserve counties" of the Adirondack and Catskill regions. California provided for setting aside and placing under management as State forests tax-delinquent cut-over lands. Indiana, New Jersey, Ohio, South Carolina, and Vermont authorized land purchases or the acceptance of gifts of land, or both, for State forests and forest parks. In Ohio the authorization covered acceptance of a gift not only of land but also of a fund of more than $1,000,000 for maintenance and further purchases.

South Carolina, besides authorizing both purchases of land and the acceptance of gifts, directed that certain waste lands be made over to the State commission of forestry for use in establishing forest-tree nurseries or for other forest purposes. Montana authorized the acceptance and setting aside of donated lands as State parks for camping and recreational use, and Minnesota provided for acquiring small tracts of land, by gift or in certain cases by purchase, for the use of the State in forestry and fire-prevention work.

Rhode Island provided for the establishment of town forests, while New York took a notable step to bring about the establishment of county forests throughout the State. Up to a maximum of $5,000 yearly, State funds are offered any county that will contribute at least equally to buy lands whose purchase for county forests is approved by the State Conservation Commission. This, together with the provision already mentioned for establishing State forests outside the Adirondack and Catskill regions, are evidences that the State is becoming aroused to the need for more public ownership as a means of lessening the accumulation of idle lands, due largely to their abandonment for farming.

County forests may become a more important factor in reforestation than has usually been imagined. The Wisconsin forest tax law, the enactment of which was mentioned in last year's report, is proving a strong incentive to the counties in that State in which tax-delinquent cut-over lands are accumulating to put these lands into county forests, in order to obtain the offered State financial assistance. In the State of Washington likewise, where as in Wisconsin tax-reverting lands pass not to the State but to the counties, the accumulation of such land is causing forest administration by the county to be seriously considered. The New York policy will be watched with interest by observers in many States.

Federal land acquisition for national-forest purposes was given a broader field in Mississippi and North Carolina, which removed limitations imposed by their original enabling acts. Missouri passed an enabling act, but limited the area that may be purchased to 2,000 acres in any one county. Mississippi, which has had a 25,000-acre limitation, now leaves the amount of land that may be acquired to the Federal Government and the State forestry commission, and North Carolina no longer limits purchases to the western part of the State.

Forest tax legislation was enacted by Connecticut, allowing exemption for growing timber until it reaches merchantable size; by North Carolina, in the form of initiation by the legislature of a constitutional amendment that will permit forest property to be taxed under uniform special provisions; and by Washington, through adoption of a constitutional amendment that accomplishes the same result.

Maine simplified her existing tax law in administrative details and as to the conditions enabling property to qualify under it, and also readjusted the rate of taxation. Idaho provided that forest-producing lands listed

with the State cooperative board of forestry may be taxed on a valuation of $1 per acre, with a yield tax when timber is cut of 12½ per cent of its stumpage value. The 50-year listing period may be extended by renewing the contract to produce timber on the listed area. Minnesota changed the tax law by substituting a fixed annual specific tax for a fixed annual ad valorem tax. Oregon passed a reforestation law which prescribes an annual tax of 5 cents per acre while the timber is maturing and a yield tax of 12½ per cent of the value of the crop when harvested. In addition the owner is required to provide protection of the growing crop from fire. All lands subject to classification come under the provisions of the law.

Many States strengthened their forest-fire legislation. Idaho authorized the State forester to enjoin the further cutting of timber on operations where the law requiring slash disposal has not been complied with, and prescribed a maximum fine of $1,000 for burning slash in the closed season without a written permit or for violating the terms of the permit. California authorized the State board of forestry to designate, upon written petition of the owners of 50 per cent or more of the forest land, any region or zone as a hazardous fire area, within which fires may not be built except at established camp sites. California also authorized municipalities to contract with the county to furnish fire protection. Washington made failure to equip all spark-emitting engines with modern spark arresters, maintained in good condition, a misdemeanor. Minnesota broadened the slash disposal law to include any accumulation of timber débris or inflammable refuse from the manufacture of lumber or other timber products. Pennsylvania authorized suit on behalf of the Commonwealth to recover the expenses incurred in connection with forest fires, and empowered the chief forest fire warden to declare a public nuisance any property which, by reason of its condition or operation, is a special forest-fire hazard and, as such, endangers other property or human life. The owner must abate such public nuisance or pay a fine plus the cost of its abatement.

Idaho made it a misdemeanor to throw any lighted cigarette, cigar, match, ashes, or flaming substance from any vehicle or upon any place where it may directly or indirectly cause a fire resulting in damage to forage on lands of the United States or the State of Idaho, or to the property of any person. The California Legislature passed a bill which was not signed by the governor, requiring motor vehicles to carry receptacles for burnt matches, pipe ashes or coals, and cigarette and cigar butts.

WORK OF THE YEAR IN STATE COOPERATION

The appropriations for cooperative work with States during the fiscal year 1929 are compared with those for the previous year and for the fiscal year 1930 in Table 1.

TABLE 1.—*Appropriations for State cooperation 1928–1930*

Item	Amount appropriated for fiscal year—		
	1928	1929	1930
For the prevention and suppression of forest fires and for the forest taxation inquiry (sections 1 to 3 of the Clarke-McNary law)	$1, 000, 000	$1, 200, 000	$1, 400, 000
For the distribution of forest planting stock to farmers (section 4 of the same law)	75, 000	75, 000	83, 000
For farm forestry extension (section 5 of the law)	60, 000	60, 000	65, 000

The amounts given above do not include the sums added in consequence of the Welch law, providing for salary increases. The appropriation under the third item is expended by the Extension Service of the Department of Agriculture. The results of the work are summarized below, except for the taxation study, which is covered on page 48. Table 2 shows in detail the Federal, State, and private funds disbursed by the States or expended under their supervision for the prevention and suppression of forest fires, and the Federal and State funds disbursed by the States for the production and distribution of planting stock.

TABLE 2.—*Cooperative expenditures in fire protection and the distribution of forest planting stock under the Clarke-McNary Act, fiscal year 1929*

State	Fire protection				Distribution of forest planting stock		
	Federal	State	Private agencies	Total	Federal	State	Total
Maine	$50,550.00	$120,010.83		$170,560.83	$1,371.52	$1,371.52	$2,743.04
New Hampshire	15,045.99	29,049.04	6,562.42	50,657.45	2,100.00	4,946.07	7,046.07
Vermont	7,448.00	5,216.36	3,817.14	16,481.50	2,000.00	8,324.36	10,324.36
Massachusetts	23,010.00	90,489.92		113,499.92	2,100.00	7,472.74	9,572.74
Rhode Island	1,374.00	10,419.42		11,793.42			
Connecticut	7,620.00	45,313.66	2,410.39	55,344.05	2,000.00	2,895.43	4,895.43
New York	56,242.00	224,629.89		280,871.89	4,200.00	112,652.57	116,852.57
New Jersey	17,464.00	60,553.09		78,017.09	2,350.00	6,628.85	8,978.85
Delaware	765.00	850.21		1,615.21	2,000.00	3,432.73	5,432.73
Pennsylvania	44,298.00	161,529.93		205,827.93	2,400.00	21,909.51	24,309.51
Maryland	7,410.00	28,347.25	1,911.20	37,668.45	2,000.00	5,624.09	7,624.09
Virginia	30,991.00	30,360.87	7,189.38	68,541.25	2,000.00	3,000.91	5,000.91
West Virginia	21,162.00	51,800.38	9,065.38	82,027.76	1,000.00	1,480.37	2,480.37
North Carolina	41,438.00	51,508.73	10,056.77	103,003.50	2,000.00	2,299.05	4,299.05
South Carolina	11,808.70	3,784.21	8,093.05	23,685.96	1,692.16	1,692.16	3,384.32
Georgia	38,380.00	21,746.56	40,081.86	100,208.42	1,970.96	1,970.96	3,941.92
Florida	35,000.00	10,583.79	26,535.13	72,118.92	555.00	802.85	1,357.85
Ohio	4,103.00	21,584.02		25,687.02	2,100.00	8,259.70	10,359.70
Illinois	850.00	5,367.78	1,350.00	7,567.78			
Indiana	1,700.00	1,779.15		3,479.15	2,000.00	12,422.09	14,422.09
Iowa					2,000.00	2,045.01	4,045.01
Missouri	7,909.90	7,909.91		15,819.81	877.08	877.08	1,754.16
Kentucky	9,311.31	9,311.34		18,622.65	2,000.00	2,397.67	4,397.67
Tennessee	21,260.00	19,577.07	8,434.96	49,272.03	1,000.00	3,410.82	4,410.82
Alabama	37,137.23	26,560.27	11,138.93	74,836.43	2,230.00	2,370.64	4,600.64
Louisiana	41,037.00	28,990.97	50,704.20	120,732.17	2,000.00	2,847.25	4,847.25
Mississippi	33,515.00	37,069.84		70,584.84			
Texas	30,722.00	31,847.39	6,512.63	69,082.02			
Oklahoma	15,830.00	8,105.21	8,987.38	32,922.59	2,220.00	4,172.84	6,392.84
Porto Rico					2,200.00	14,382.47	16,582.47
Montana	20,228.00	15,168.61	50,026.12	85,422.73	1,132.00	1,132.00	2,264.00
Idaho	52,371.00	53,981.88	135,023.96	241,376.84	2,000.00	4,333.49	6,333.49
Kansas					2,000.00	2,321.33	4,321.33
Nebraska					2,100.00	8,132.00	10,232.00
Colorado					2,000.00	2,050.40	4,050.40
South Dakota	375.00	4,067.00		4,442.00			
Wyoming					972.17	972.17	1,944.34
North Dakota					2,000.00	3,591.54	5,591.54
New Mexico	1,916.00	5,683.00		7,599.00			
California	55,595.00	110,116.92	74,803.79	240,515.71	687.00	700.94	1,387.94
Hawaii					2,400.00	19,190.12	21,590.12
Washington	72,355.00	66,997.54	226,808.98	366,161.52	2,000.00	2,143.02	4,143.02
Oregon	67,912.00	65,038.72	213,548.49	346,499.21	2,000.00	2,013.14	4,013.14
Wisconsin	33,136.00	120,577.93		153,713.93	1,533.00	3,406.30	4,939.30
Michigan	77,694.00	307,506.33		385,200.33	2,000.00	5,568.77	7,568.77
Minnesota	73,883.00	226,223.80	19,611.75	319,718.55			
Administration and inspection	77,680.88			77,680.88	1,181.18		1,181.18
Total	1,146,528.01	2,119,658.82	922,673.91	4,188,860.74	74,372.07	295,244.96	369,617.03
Forest tax studies	61,493.50						
Unexpended balance	1,780.49				1,107.93		
Total appropriation	1,209,802.00				75,480.00		

In addition to the expenditures for fire protection shown in Table 2, approximately $116,000 was reported as expended independently by private individuals and associations. A much larger sum was undoubtedly so expended. In some States very substantial contributions were thus made to the protective work.

COOPERATIVE PROTECTION OF STATE AND PRIVATE FOREST LANDS FROM FIRE

State activity in forest-fire protection is advancing slowly but steadily from the stage in which the State assumes no responsibility and takes no part to the stage now reached in a few States, where State and private owners and the Federal Government are carrying through a cooperative program of effective state-wide protection. In 1928 the States reported some form of systematic protection on 235,000,000 acres, 57 per cent of the 414,000,000 acres of State and private lands in need of such protection. The progress made in the last four years is shown in Table 3.

TABLE 3.—*State and private lands under organized protection*

Calendar year	Area	Gain over previous year
	Acres	*Acres*
1925	178, 200, 000	
1926	195, 200, 000	17, 000, 000
1927	202, 100, 000	6, 900, 000
1928	235, 000, 000	32, 900, 000

Of the 179,000,000 acres needing but not yet receiving protection 88 per cent lies in the South. Here the work is in the early stage of earnest but poorly financed State leadership. Yet there are indications that state-wide protection is on the way. West Virginia now requires private owners to protect their forest land or pay the State for the work. Similar legislation has been proposed in Kentucky. Virginia requires the counties to pay for the suppression of fires under the direction of the State forest wardens, but has not yet provided enough money to make the administration of the law state-wide.

In Mississippi a bill was introduced last winter providing for the establishment of protective districts upon petition of a majority of the forest-land owners. Within such districts all the forest-land owners would be required to support organized protection maintained through an owners' associat on. The bill affords an excellent example of the tendency to seek local compulsory forest-fire protection where a majority of the owners want it. In various Southern States, including Louisiana, Texas, Oklahoma, Florida, Tennessee, North Carolina, Kentucky, and Virginia, protection by such local associations is becoming well established. Owners who are paying assessments to protect, along with their own land, that of nonpaying owners of intermingling land soon begin to favor a requirement by the State that all owners protect their land or pay for its protection.

The Cape Cod forest-fire prevention experiment, begun in January, 1926, by the Massachusetts Forestry Association in cooperation with the Massachusetts Division of Forestry and the Forest Service, was completed with the fall fire season of 1928. Its aim was to determine the effectiveness of intensive educational prevention work in fire control. During the three years prior to the experiment $29,487 was spent for forest-fire suppression. During the three years of the experiment the total expenditure for educational work and suppression together was $23,551. During the three years before the experiment 28,089 acres was burned over; during the three years of the experiment, 5,885 acres. Thus with an outlay 20 per cent less a 79 per cent reduction in the area burned took place.

Revised estimates of the cost of protecting State and private lands from forest fires in the several States were initiated during the year, to be completed January 1, 1930. The estimated cost of protection in each State partly determines the amount of the Federal allotment of funds. After their submittal by the States the estimates will be analyzed and correlated by the Forest Service with the assistance of a special committee of the national association of State foresters.

The record of forest fires for the calendar year 1928 is given in Table 4. As compared with 1927, a large increase in the area burned is shown. The 1927 record for protected lands was 2,784,450 acres, as against 4,428,500 acres in 1928, and for unprotected lands was 35,747,380 acres as against 39,502,810 in 1928. For the unprotected areas, the available data are too fragmentary and inexact to permit of more than rough estimates, though the records are becoming steadily more complete. Regarding the protected area, it should be borne in mind that it was over 35,000,000 acres greater in 1928 than in 1927. An abnormally severe spring fire season in the Middle Atlantic, Gulf, and Central States and a bad late fall season in the Northwest increased the area burned over.

TABLE 4.—*Summary of forest-fire statistics, by groups of States, for the United States, exclusive of Alaska, calendar year 1928*

Group of States [1]	Number of fires				Damage			
	On protected area	On unprotected area	Total	Per cent	On protected area	On unprotected area	Total	Per cent
United States	40,579	136,783	177,362	100.0	$8,583,620	$74,350,600	$82,934,220	100.0
Northeastern	3,098		3,098	1.8	407,470		407,470	.5
Middle Atlantic	4,437		4,437	2.5	1,075,500		1,075,500	1.3
Southeastern	3,438	35,991	39,429	22.2	653,540	22,606,200	23,259,740	28.1
Gulf	12,987	99,120	112,107	63.2	2,036,070	50,359,270	52,395,340	63.2
Central	1,967	1,301	3,268	1.8	420,590	740,500	1,161,090	1.4
Lake	3,065		3,065	1.7	164,570		164,570	.2
Rocky Mountain	3,643	177	3,820	2.2	475,700	59,800	535,500	.6
Pacific	7,944	194	8,138	4.6	3,350,180	584,830	3,935,010	4.7

AREA, IN ACRES, BURNED

Group of States [1]	On protected area							
	Forest land					Nonforest land		
	Mature or merchantable	Protection, forest	Young growth		Total	Protection, brush and grass	No protection or forest value	Total
			Will restock	Will not restock				
United States	746,250	78,370	1,854,400	174,150	2,853,170	1,478,820	96,510	1,575,330
Northeastern	12,780		33,250	570	46,600	27,440	8,970	36,410
Middle Atlantic	37,040		46,340	14,200	97,580	73,000	7,740	80,740
Southeastern	99,860	4,340	150,110	21,070	275,380	4,650	1,810	6,460
Gulf	366,720	950	1,127,940	69,610	1,565,220	88,260	10,830	99,090
Central	83,150	2,980	96,620	1,030	183,780	200	4,550	4,750
Lake	1,820		113,570	750	116,140	76,070	44,750	120,820
Rocky Mountain	14,890	13,120	44,200	19,030	91,240	31,270	2,110	33,380
Pacific	129,990	56,980	242,370	47,890	477,230	1,177,930	15,750	1,193,680

Group of States	On protected area		On unprotected area	Grand total	Per cent
	Total protected area burned	Per cent			
United States	4,428,500	100.0	39,502,810	43,931,310	100.0
Northeastern	83,010	1.9		83,010	.2
Middle Atlantic	178,320	4.0		178,320	.4
Southeastern	281,840	6.4	21,011,810	21,293,650	48.5
Gulf	1,664,310	37.6	18,059,790	19,724,100	44.9
Central	188,530	4.3	195,650	384,180	.9
Lake	236,960	5.3		236,960	.5
Rocky Mountain	124,620	2.8	44,960	169,580	.4
Pacific	1,670,910	37.7	190,600	1,861,510	4.2

[1] Northeastern group—New England States and New York. Middle Atlantic group—New Jersey, Pennsylvania, Delaware, and Maryland. Southeastern group—Virginia, West Virginia, North Carolina, South Carolina, Georgia, and Florida. Gulf group—Alabama, Mississippi, Louisiana, Texas, Oklahoma, and Arkansas. Central group—Kentucky, Tennessee, Ohio, Indiana, Illinois, and Missouri. Lake group—Michigan, Wisconsin, and Minnesota. Rocky Mountain group—Montana, Idaho, Wyoming, South Dakota, Colorado, Arizona, New Mexico, Nevada, and Utah. Pacific group—Washington, Oregon, and California.

COOPERATION WITH STATES IN TREE PLANTING

A growing interest among farm-land owners in reforesting their idle acres and in maintaining the productiveness of their existing woodlands is evidenced by the annual increase in the number of young trees distributed by the cooperating States. Last year nearly 29,000,000 State-grown trees, and an additional number purchased from commercial nurseries, were used by farmers in planting more than 31,000 acres. A million more trees were planted on farm lands in 1928 than in 1927. Many of the State cooperative nurseries which have been established since the passage of the Clarke-McNary law are not yet on a quantity-production basis, and a large increase in the number of available trees may be expected in the next few years. Seventy-five per cent of the planting stock distributed to farmers last year was propagated in the four States of New York, Pennsylvania, Massachusetts, and Ohio.

Cooperation under this section of the law has been requested by agencies in two additional States, South Dakota and Utah, and will be granted as soon as legislation is enacted by those States authorizing the agencies to engage in the production and distribution of planting stock.

Maintaining its policy of assisting the cooperating States in securing certain kinds of tree seed at reasonable cost, the Forest Service cooperative seed collection project on the Chippewa National Forest in Minnesota was continued. Over 1,000 pounds of Norway pine seed was furnished to the States participating in the project.

A conference of Forest Service and State officials in charge of tree-planting work was held in North Dakota during the year. Commercial nurserymen of the region were officially represented at the conference. A better understanding of the purposes and problems of the tree-distribution work as handled by the States was secured, definite planting objectives for the Great Plains States were adopted, and plans were formulated for the selection of tree species best suited to the area and for greater uniformity in distribution methods, prices of stock, and inspection of proposed and established plantations.

The allotments made to the States cooperating, and their expenditures, were shown in Table 2.

COOPERATION WITH STATES IN FARM FORESTRY EXTENSION

Management of farm woodlands so that they may bring the fullest returns to the farmer is an important part of a broad program of forestry for the State. It is furthered through projects and programs of the various colleges of agriculture and through the State forestry departments. Federal cooperation in this work, authorized under section 5 of the Clarke-McNary law, is conducted as a part of the extension program of the several State agricultural colleges and is administered by the Extension Service of the Department of Agriculture with the cooperation of the Forest Service. The Federal appropriation of $60,000 for the last fiscal year was used mostly for the employment of extension foresters.

Thirty-one States carried on cooperative extension work in farm forestry. Colorado discontinued its project, and Wyoming enrolled on the list for the first time. A good increase in activities and accomplishments is shown by the record for the year ended November, 1928, the latest available information. As a result of this cooperative effort, improved practices in some phase of forestry were adopted on 18,902 farms. Of these, 3,751 farms adopted better practices for the first time. The management of existing woodlands constituted a project on 5,476 farms, an increase of 967 over last year, with a corresponding increase of 85,085 acres involved, making the total 307,224 acres. The 6,082 forest plantations established this year through the efforts of the extension foresters added 16,471 acres. In addition, 3,715 farmers planted windbreaks.

The boys' and girls' 4–H clubs in forestry increased their membership by 864, making a total enrollment of 4,031, and 2,719 completed their projects. This activity among the juniors on the farms is to be found in 27 States, but is of largest importance in New York, New Jersey, New Hampshire, and Wisconsin.

NATIONAL-FOREST ADMINISTRATION

The expenditures for national-forest administration, protection, improvement, reforestation, and extension are shown in detail on page 59, totaling $21,108,507.16. This is exclusive of expenditures for administration of the

Forest Service as a whole (i. e., general overhead). Increases over last year's national-forest expenditures included $1,217,962.30 more for improvements, of which $1,114,054.62 was in the roads and trails items, $621,051.05 more for protection, $122,499.56 for administration, and $78,637.66 for reforestation. An apparent decrease of $959,283.44 for national-forest extension was due to the fact that the purchase of the Waterville tract in the White Mountains National Forest late in the fiscal year 1928 was accomplished from a 1929 appropriation which Congress made available for earlier use, as was explained in last year's report.

The appropriations of Federal funds for the national-forest enterprise in the fiscal years 1928, 1929, and 1930 are shown in Table 5.

TABLE 5.—*Appropriations of Federal funds for the national forest enterprise, 1928–1930*

Item	1928	1929	1930
General expenses of administration, protection, and improvement	$6,488,865.00	$7,119,673.00	$7,195,230.00
Specifically for—			
Fire and insect control	1,182,003.43	1,269,996.57	150,000.00
Improvements, tree planting, land and resource surveys, and land adjustments	880,450.00	1,005,270.00	1,066,050.00
Land acquisition	1,994,843.40	1,005,156.60	2,000,000.00
Roads and trails (construction and maintenance) needed primarily for forest protection and development	4,654,086.78	3,540,511.91	3,625,855.89
Highway construction and maintenance primarily to meet public needs, as a recognition of Federal responsibility created by ownership of untaxed lands	4,240,000.00	4,500,000.00	4,500,000.00

The figures given in Table 5 in the first three items of the 1929 column do not agree with those reported a year ago. The differences in the first and third items were due to the operation of the Welch law, providing for salary increases which added $305,073 and $8,820, respectively, to these two items. The large difference in the second item, amounting to $1,198,104.03, was brought about by a deficiency appropriation of $1,200,000 on account of fire expenditures and by certain accounting adjustments that diminished by $1,895.97 the balance available in 1929 from the $100,000 fire fund expendable either in 1928 or 1929.

Last year's report explained in detail the remaining differences between the 1929 and the 1928 appropriations, due principally to increased provision for fire control, reforestation, and timber sale and range management work. The differences between the 1929 and 1930 appropriations in the first three items resulted from the following changes:

The first item was increased by $59,714 to provide for the employment of additional protective guards and for the purchase of equipment for fire fighting. Further additions of $16,000 and $2,100 to this item provided, respectively, for the purchase of a new boat for use in Alaska and for Welch law salary increases, while the provision for Washington office expenditures in connection with national-forest administration was reduced by $2,157 and the provision for the Ogden supply depot by $100.

The second item is deceptive in two particulars—first, the figures given for 1929 and 1930 comprise solely the specific appropriations for fire control, the provision for insect control having been carried in 1929 from the second into the first item through a shift of $75,000; second, the entry for 1930 shows only the amount carried by the agricultural appropriation act, whereas the 1929 entry includes the amount made available during the year by a deficiency appropriation. Instead of appropriating a large sum in advance for fire fighting, Congress looks to the Forest Service to meet whatever situation develops, relying upon a deficiency appropriation to replenish its funds to the extent necessary. The $150,000 shown as appropriated for 1930 is in point of fact the same amount as was initially appropriated for the same purpose by the 1929 agricultural appropriation act. In both years it included a $100,000 fire fund and $50,000 for aerial patrol. Owing to the severe fires of

the summer and early fall of the present calendar year, a deficiency appropriation of at least $3,000,000 for the fiscal year 1930 will probably have to be sought.

Under the third item in Table 5, the 1930 appropriations increased by $10,000 the provision for camp-ground improvements, by $55,000 that for range improvements, and by $10,088 the funds available for the construction of protective improvements (principally lookout towers and houses). Reductions were effected by the disappearance of the special 1929 provision of $9,000 for building a dam at Cass Lake, Minn., and by decreases of $2,220 in the tree-planting funds, $3,042 in those for estimating and appraising the national-forest resources, and $46 in the provision for land classification and examination.

The apparent difference between the 1929 and 1930 appropriation under the fourth item in Table 5 was in consequence of the purchase of the Waterville tract, already explained. The last two items in the table show an identical provision with that of the previous year for the so-called "forest highways," but a small increase in the funds available for the "forest-development" roads. The increase is due wholly to the fact that 10 per cent of the receipts from the national forests go into the forest-development road fund; both for 1929 and for 1930 the amount in excess of $3,000,000 shown under this item is derived from the receipts of the previous fiscal year.

It should be said with regard to the road funds that unexpended balances carried forward from one fiscal year to the next cause considerable variations between the amounts shown in Table 5 as appropriated for each year and the amounts actually available for expenditure. The table disregards carry-overs of road funds, since not to do so would tend to obscure rather than to clarify the roads situation.

PERSONNEL TRAINING

In previous reports some mention has been made of the attention that the Forest Service has given to training its personnel in the efficient handling of the highly diversified tasks that have to be performed. One of the means to this end has been discussion courses carried on by mail, for groups of field men scattered on the national forests of a district. In the winter of 1927–28 a service-wide training project had to do with accounting, and particularly with cost accounting.

The determination of unit and activity costs in the work of the Forest Service is a particularly vexing question because of the diversity of activities, the difficulty of making accurate and uniform charges for time of employees, and the problems raised in making satisfactory distribution of indirect and overhead charges. More than 100 men pursued the study. It was designed primarily to stimulate the thoughtful application of recognized principles and practices of accounting to the financial and management problems confronting each individual. The "conference by correspondence" device secured an interchange of knowledge and experience. On the basis of the conclusions reached, a group of skilled accountants prepared plans for an extensive revision of the method of cost accounting used by the Forest Service. This new and, it is believed, sounder system of cost accounting was put into experimental use on a few national forests July 1, 1929. After a year of trial and development it will be installed on all national forests.

During the winter of 1928–29 over 400 men, including some of the highest rank, participated in a similar study of executive management. Accepted principles of industrial executive management were assembled and circulated in a form designed to stimulate discussion and relation to the executive-management problems of each individual. This study, like the one on cost accounting, will be followed up with such steps as seem most appropriate for strengthening the executive management of the national forests.

JOB ANALYSIS AND PLANNING

In the report for the fiscal year 1925 some account was given of the methods employed in controlling the expenditure of the 80 per cent of the regular appropriation for the Forest Service which goes into salaries, wages, travel, and other items that form part of the cost of personal service. In the spring of 1927 an important new development was started in this field. The work of local forest officers is so scattered in time and place that all foreseeable work needs to be organized in advance and routed in trip plans to afford the best sequence of jobs. For still better control of the use of time a systematic analysis of jobs was undertaken. The method followed was to set up the objectives of each ranger district, determine all of the jobs necessary to attain them, and establish for

each job standards of perfection, intensity, methods, and practice. Time studies disclosed the amount of time needed to meet each job standard. The quantity per year of recurrent work was also ascertained and the best time to handle each phase of it was decided.

Such an analysis raises for decision many questions of policy and practice. Correlation and coordination in purposes, methods, standards, and requirements are admirably served, unwise or relatively unimportant uses of time are revealed, and a conclusion is established as to the number of days of work required to carry the job load and the approximate weight of the load for each ranger district. The same method is now being applied to the work of the forest supervisors, and in a somewhat modified form has been employed for the Washington office of the Forest Service. It has produced important betterments in organization and economies in financial management, revealing opportunities to get work done that would otherwise appear beyond the power of the available personnel. The higher up it is carried, the more important does the question of function become, until it reaches the very heart of organization adjustments and structure. It should make a large contribution toward working out for the entire Forest Service the most efficient mechanism of organization, from top to bottom.

THE NATIONAL-FOREST PROPERTIES

The gross area of the national forests on June 30, 1929, was 184,564,953 acres. This included 24,814,433 acres not owned by the United States. The net area was therefore 159,750,520 acres. The gross area increased 200,134 acres; the net area 269,664 acres.

By Executive orders, the Camp Humphreys and Tobyhanna Military Reservations, in Virginia and Pennsylvania, respectively, were removed from national-forest status, reducing the gross area by 26,443 acres, while exchanges with private owners of lands outside the former forest boundaries added 33,968 acres, purchases of nursery sites added 90 acres, and area recomputations based on better surveys and land data added 11,649 acres. The other gross area changes of the fiscal year are listed in Table 6.

TABLE 6.—*Additions to and eliminations from the gross areas of the national forests made by acts of Congress, presidential proclamations, Executive orders, and State land exchanges*

National forest	State	Additions	Eliminations	National forest	State	Additions	Eliminations
		Acres	*Acres*			*Acres*	*Acres*
Absaroka	Montana		[1] 3,072	Missoula	Montana	[1] 4,480	
Blackfeet	do		[2] 1,099	Monongahela	Virginia and West Virginia.	[4] 103,550	[4] 98,100
Chelan	Washington		[3] 43,297	Olympic	Washington		[2] 34,591
Chugach	Alaska		[3] 8	Powell	Utah		[1] 12,455
Crook	Arizona		[3] 36	Shoshone	Wyoming	[1] 50,560	[1] 85,472
Eldorado	California and Nevada.	[4] 8,299		Siuslaw	Oregon		[2] 9,644
Flathead	Montana		[2] 292	Snoqualmie	Washington		[2] 2,756
Gallatin	do		[1] 27,008	Teton	Wyoming		[1] 95,185
Harney	South Dakota	[4] 2,440		Toiyabe	Nevada		[3] 800
Huron	Michigan	[4] 423,889		Tongass	Alaska		[3] 234
Lassen	California		[1] 24,919	Tonto	Arizona		[3] 85
Michigan	Michigan		[4] 13,095				

[1] Made by acts of Congress.
[2] Made by State land exchange.
[3] Made by Executive order.
[4] Made by presidential proclamation.

The Huron National Forest, in Michigan, was created during the year, and the 423,889 acres entered in Table 6 includes 39,000 acres also reported last year, as added to the Michigan Forest. The duplication makes discrepant by this amount the gross-area statements for the two years.

The changes made by acts of Congress in the Absaroka, Gallatin, Lassen, Powell, Shoshone, and Teton Forests were to readjust the boundaries between the Yellowstone, Lassen, and Bryce Canyon National Parks and adjoining national forests and to create the Grand Teton National Park. The addition made by Congress to the Missoula was in correction of an error in a previous bill. The additions made by Executive order to the Eldorado and Harney (the former under the authority of a specific act of Congress) brought within these units small adjoining areas of public lands found to

have sufficient forest values to justify their inclusion. The Monongahela changes were to exclude from the unit portions in which purchases have been found inadvisable, and to include new areas offering opportunities for desirable acquisitions. The Huron addition represents essentially the conversion of a former "purchase area" into an organized national forest.

While the major part of the land in the Huron still remains to be acquired, the new unit contains a substantial nucleus of Federal lands formerly included in the Michigan National Forest and a certain amount of lands acquired outside that unit. In connection with the establishment of the Huron, it was found advisable to exclude a portion of the area formerly embraced in the Michigan, since its acquisition is not deemed feasible. The resulting elimination appears in Table 6, under the Michigan. The latter unit is now confined to the northern peninsula of the State.

The rest of the changes shown in the table are all of very minor character and were due to a variety of considerations of administrative convenience.

What part of the public lands should be added to the national forests because of their actual or potential timber and watershed values should be determined at an early date. With the increasing scarcity of timber and the increasing importance of water conservation many areas previously thought of relatively low value should be considered anew. It is true that section 8 of the Clarke-McNary law authorizes the Secretary of Agriculture to ascertain and determine the location of public lands chiefly valuable for stream-flow protection or for timber production, which can be economically administered as parts of national forests, and to report his findings to the National Forest Reservation Commission; but a wide range of local interests are involved, and present jurisdiction over the lands rests in the Department of the Interior. However, the beneficial effects of regulated use under national-forest administration have been so widely and thoroughly demonstrated that there should be no difficulty in reaching a conclusion regarding the form of use under which certain classes of the remaining public lands will have the highest permanent economic and social value. Field officers of the Forest Service have examined and submitted reports upon 44 areas, containing 1,264,330 acres of public land and estimated to support 2,333,000,000 board feet of timber, upon which action remains to be taken. Still other areas remain for consideration. Of the areas reported on, five have been approved by the National Forest Reservation Commission under authority of section 8 of the Clarke-McNary Act and referred by the President to Congress. No additions were made to the national forests last year under the procedure provided by that act.

LAND ACQUISITION THROUGH EXCHANGE

Additional exchanges were worked out with the State of Michigan whereby the Government will acquire title to State lands within national forests, while the State will acquire public lands of the United States within existing or contemplated State forests. Thus the consolidation of both classes of public forests is aided. A further exchange with the State of South Dakota was initiated during the year. The exchanges initiated in earlier years are all progressing toward final consummation. Through them the States of Washington, Oregon, California, Idaho, Montana, South Dakota, and Michigan have been enabled to replace widely scattered holdings, impracticable for effective administration, with compact holdings easily administered and of great public value. An exchange with New Mexico awaits a constitutional amendment. The remaining Western States apparently prefer to retain their present holdings or to use them as base for other selections.

The acquisition of private lands through exchange was facilitated by acts of Congress extending the provisions of the forest exchange act to privately owned lands within 6 miles of the exterior boundaries of national forests in the State of Montana, and authorizing the exchange of privately owned lands within the Lincoln National Forest, in New Mexico, for unreserved public lands in that State. During the calendar year 1928 a net total of 89,798 acres was added to the national forests through the exchange of 25,269 acres of national-forest land and $272,371 worth of national-forest stumpage for 115,067 acres of private lands. The Secretary of Agriculture approved and referred to the Secretary of the Interior for further action 145 new cases, offering 262,737 acres of privately owned lands in exchange for 22,054 acres of national-forest land and

236,006,000 board-feet of national-forest stumpage. Since the land-exchange legislation was enacted 391 exchanges have added 485,739 acres in return for 132,014 acres of national-forest land and $1,020,678 worth of national-forest stumpage—a net addition of 353,725 acres. The national-forest stumpage granted will be more than offset by the mature stumpage on the acquired lands.

The Forest Service safeguards from serious reduction county and Federal revenues by limiting to 10 per cent of the gross receipts in any State, and ordinarily to 10 per cent of the timber-sale receipts alone, the total value of the stumpage used in exchanges in any one year; and this necessitated the postponement of some desirable exchanges.

Privately owned forest lands within and contiguous to the national forests are in the main integral parts of the natural logging units or working circles with which the Forest Service is dealing. Frequently they constitute serious obstacles to orderly and sound plans of protection and utilization. Cut-over, slash-covered, and inadequately protected lands menace the national forests and increase the cost of protection. After the present stands of timber have been removed the probability is that the lands will be disposed of for grazing use or neglected, with ultimate loss of their potential value for forest production. Both the location and the diverse ownership of much of the land militate against its effective management independently of the national forests.

There are almost 25,000,000 acres of non-Federal lands within the forests, of which roughly some 12,000,000 to 14,000,000 acres should be acquired, as well as certainly several million acres of contiguous outside land. The acquisition of this 15,000,000 to 20,000,000 acres raises a very large question of ways and means. One answer is suggested by the act of February 7, 1929, authorizing the exchange of unreserved public lands in New Mexico for lands in the Lincoln National Forest. If that exchange is consummated, lands of great public value will be acquired, and lands which have been held open for private appropriation will pass to private ownership. Thus not one but two broad public purposes will be accomplished. The 190,000,000 acres of unreserved and unappropriated public lands offer further opportunities along this line.

LAND ACQUISITION THROUGH PURCHASE

Title was taken under the Weeks law, as amended by the Clarke-McNary law, to 189,474 acres, at a cost of $891,209.29. The average cost per acre, $4.70, is less by 44 cents than the previous average of all purchases.

Purchases totaling 464,208 acres, at an average price of $3.85 per acre and creating a total obligation of $1,786,461.15, were approved by the National Forest Reservation Commission during the year. Included was a small area of Pennsylvania virgin white pine and hemlock forest that is now made a part of the Allegheny National Forest, and that is almost unique as an example of the original stand.

The distribution by States of the lands fully acquired is shown in Table 7.

TABLE 7.—*Acreage of timberland acquired in the fiscal year 1929 and total acquired to July 1, 1929, by States*

State	Acquired in 1929	Average price per acre, 1929	Total acquired to July 1, 1929
	Acres	*Dollars*	*Acres*
Alabama	4,865	5.03	96,741
Arkansas	27,002	2.83	146,378
Georgia	44,216	4.76	244,952
Maine	232	6.00	33,361
Michigan	20,758	1.16	73,100
Minnesota	28,046	1.70	32,139
New Hampshire	9,584	8.64	460,474
North Carolina	844	5.54	370,495
Pennsylvania	39,769	8.56	291,337
South Carolina	266	6.08	42,378
Tennessee	6,548	6.02	372,958
Virginia	1,973	5.18	588,954
West Virginia	5,472	3.62	242,967
Total or average	189,575	4.70	2,996,234

The average cost of all lands fully acquired, not including overhead, has been $5.11 per acre; the total, $15,306,420.80.

The National Forest Reservation Commission approved the establishment of nine new purchase areas—the Osceola, Ocala, and Choctawhatchee in Florida, the Oneida, Flambeau, and Moquah in Wisconsin, the Keeweenaw in Michigan, the St. Croix in Minnesota, and the Green Mountain in Vermont. The Ocala and Choctawhatchee include long-established national-forest units created by the reservation of public lands; they are made purchase units to facilitate the

consolidation and rounding out of the present properties.

Several adjustments of the boundaries of purchase areas were approved by the commission. Those of the Monongahela, in West Virginia, were radically readjusted with a net area decrease of 47,743 acres. The Nantahala and Savanna units were combined and somewhat modified. The Catahoula unit in Louisiana was revised and its area increased from 50,000 to 78,700 acres. To include integrally related lands, the Ouachita purchase unit in Arkansas was extended by 200,000 acres. Numerous changes in the boundaries of the White Mountain National Forest in New Hampshire effected a net increase of 5,430 acres, while 380,000 acres were eliminated from the Pisgah, in North Carolina, to exclude large areas which are not purchasable.

While neither the Weeks law nor the Clarke-McNary law limits purchases geographically, the lands bought have been east of the ninety-fifth meridian, where the forest situation is acute, the need for public action urgent, the population and timber consumption largest, the number of important navigable streams greatest, the proportion of forest land assured of permanent timber growing smallest, and the acreage of publicly owned forest land relatively negligible. Under the Weeks law the major objective was the protection of navigable streams, though with timber production a natural concomitant. The Clarke-McNary law added timber production as a major purpose, but with watershed protection as an accompanying result, since all lands purchased must be on the watersheds of navigable streams. Along with these two closely allied major purposes the purchase policy furthers the effective participation of the Nation in the broad task of forest perpetuation through the development and demonstration of practicable methods of forest management on a large scale, and makes possible the coordination with timber production and stream-flow protection of such related uses as outdoor recreation and wild-life conservation.

Where watershed protection is the dominant consideration the national-forest units must be large enough to embrace appreciable parts of the watershed. If timber production is the first concern, the units must be of sufficient size to allow economy of operation. But where it is desired to stimulate private forestry by developing and demonstrating successful methods of management, a larger number of smaller units, well distributed, will accomplish most.

The original Weeks law program contemplated the acquisition of 1,000,000 acres in the White Mountains and 5,000,000 acres in the southern Appalachians. But while this objective was being slowly and partially attained forest exploitation continued and was even accelerated. After an exhaustive inquiry the Senate select committee in 1924 recommended that timber production be made a primary objective of the purchase work, that the work be extended into new regions, and that an enlarged purchase program be adopted. The ensuing Clarke-McNary law and the McNary-Woodruff law gave legislative effect to these recommendations as national policies. The present task is to give them adequate application.

As was stated in last year's report, a survey of the situation and its requirements led to the approval by the National Forest Reservation Commission, early in 1928, of a program for the eventual acquisition of 9,600,000 acres of land, contingent, of course, upon the necessary concurrence of the States. Substantial purchases have since been approved by the commission. A resurvey indicates that to give full effect to the program ratified by the National Forest Reservation Commission a year ago will entail the purchase of 3,770,000 acres to consolidate previously existing national forests on the headwaters of navigable streams; 1,144,000 acres to consolidate previously existing national forests in Michigan and Minnesota; 1,300,000 acres within the approved or proposed new national forests to protect the headwaters of navigable streams; and 3,260,000 acres within the additional approved or proposed national-forest units in the southern pine region and the northern Lake States intended primarily to aid in timber production and to demonstrate forestry practice; or approximately 9,475,000 acres all told.

To carry out the program calls for a definite fiscal policy and plan. As with other large, long-time governmental programs such as the public-building program and the Federal-highway program, the best results can be obtained under definite legislative authorizations covering from 5 to 10 year periods. This makes possible the maintenance of a trained and experienced in place of a fluctuating personnel, and continuous, orderly progress. The purchase work can be most

economically and efficiently planned and executed under assurance of the future availability of funds. The 3-year authorization contained in the act of April 30, 1928, has been very helpful, but it expires with the fiscal year 1931. The enactment by Congress of a succeeding measure embodying a fiscal plan and authorization for a 10-year period would greatly facilitate the accomplishment of the whole project.

SPECIAL USES

At the close of the calendar year 1928, 33,310 special-use permits were in effect, of which 15,760 were free and 17,550 involved an annual rental charge. The free permits increased by 451; the pay permits by 429. Most of the free permits are granted to facilitate the use of other forest land or resources; most of the pay permits for occupancy of hotel, resort, and private-cottage sites. Receipts totaled $287,119.08.

CLAIMS AND SETTLEMENT

Favorable reports were made on 168 and unfavorable on 31 homestead claims. Most of the lands involved had been listed for entry under the forest homestead act, and the unfavorable reports were usually because of noncompliance with the requirements of the law relating to residence and cultivation.

Favorable reports were made on 110 and unfavorable on 25 mineral claims. Attempts continue to employ the mineral land laws for purposes other than mineral development. Citizens were recently invited by circular letter to join California clubs which would obtain and use for recreational purposes desirable tracts within the national forests, to be located as mineral claims. A modification of the present laws to prevent such fraudulent practices without hampering legitimate development of the mineral resources is urgently required. A law which would give mineral claimants title to the ore body and the right to use so much of the surface as is needed in connection with the mining operations, but would retain title to the surface in the United States, would correct the evil.

COORDINATION OF NATIONAL PARKS AND NATIONAL FORESTS

No projects were referred to or considered by the coordinating committee on national parks and forests during the year. Some questions remain relating to the boundaries of the Yosemite and the Sequoia National Parks in California and the tentatively suggested Cliff Cities National Park in New Mexico, but they were not in such status as to permit of their further consideration by the committee.

The adjustment of the boundaries of the Yellowstone National Park recommended by the committee has been accomplished in part by the acts of Congress approved February 26 and March 1, 1929. The remaining proposals are to be considered by a special boundary commission, appointed by the President in pursuance of an act of Congress. The setting aside of the Grand Teton National Park and the boundary adjustments increasing the Lassen Volcanic National Park in California and the Bryce Canyon National Park in Utah have already been mentioned. A bill to create the Ouachita National Park from lands now parts of the Ouachita National Forest, in Arkansas, passed both Houses of Congress but was not approved by the President.

NORTHERN PACIFIC LAND-GRANT LEGISLATION

The right asserted by the Northern Pacific Railway Co. to select approximately 2,800,000 acres of indemnity lands within the national forests of the Northwest was terminated by an act of Congress which became law June 25, 1929. The law removed from the operation of the grants made to the railroad the lands in question, at the same time providing that the railroad shall be entitled to compensation for the lands if and when the right to compensation shall be established through decision of the courts. The law also declared a forfeiture of the unsatisfied indemnity selection rights of the railroad, with provision for the institution of court proceedings to determine the disputed questions of law and fact which arose in connection with the consideration of the case by the joint committee of Congress created to hear the evidence.

PROTECTION FROM FIRE

The number, size, and causes of fires on the national forests in the calendar year 1928, as compared with those of the previous year and the average of the past 5-year period, are shown in Table 8.

TABLE 8.—*Comparison of fires on national forests, calendar years 1928, 1927, and 5-year average for period 1924–1928*

	Number of fires			Percentage of total		
	1928	1927	Average 1924–1928	1928	1927	Average 1924–1928
Class:						
Burns of 0.25 acre or less	3,873	3,588	3,868	55.96	63.02	53.40
Burns between 0.25 and 10 acres	1,914	1,443	2,025	27.66	25.35	27.95
Burns of 10 acres and over	1,134	662	1,351	16.38	11.63	18.65
Total	6,921	5,693	7,244	100.00	100.00	100.00
Cause:						
Railroads	281	297	328	4.06	5.22	4.53
Lightning	3,195	3,074	3,616	46.18	54.00	49.92
Incendiarism	690	397	754	9.97	6.97	10.41
Brush burning	230	163	234	3.32	2.86	3.23
Lumbering	133	77	138	1.92	1.35	1.90
Camp fires	717	596	705	10.36	10.47	9.73
Smokers	1,345	875	1,179	19.43	15.37	16.28
Miscellaneous	330	214	290	4.76	3.76	4.00
Total	6,921	5,693	7,244	100.00	100.00	100.00

Calendar year	Total area of national-forest land burned over	Total damage of national-forest land burned over	Total cost of fighting fires exclusive of time of forest officers
	Acres	*Dollars*	*Dollars*
1928	398,900	833,122	1,193,038
1927	170,473	298,733	646,624
5-year average, 1924–1928	439,818	1,595,977	1,289,540

On the whole the showing in 1928 fell below that in 1927, which bettered that of 1926 at practically every point. The number of fires covering 10 acres or more almost doubled, approaching the 5-year average; and the number of man-caused fires increased 42 per cent and exceeded the 5-year average. Of all classes of man-caused fires only those caused by railroads showed any decrease.

The area of national-forest land burned increased 134 per cent and rose to within 9 per cent of the average for the 5-year period, which included two bad years; the total damage exceeded $800,000; and the fire-fighting expenditures (mostly on large fires) approached $1,200,000.

The climatic conditions of 1928 were about what must normally be expected. Prolonged drouth, wind, and low humidity created an extremely dangerous situation in California; Oregon and Washington had for a time unusually high temperature and low humidity; a troublesome period occurred in Idaho and Montana after the season had supposedly been closed; and in the Southwest the season was abnormally long. On the other hand, summer rains were unusually abundant during what is ordinarily the peak of the season in the northern Rocky Mountain and North Pacific States, and there was no such disastrous bunching of lightning fires as in 1926 wrought terrible destruction in the Idaho white pine.

That great improvement has been made in the protective system with increasing experience and through the unremitting effort for better organization, personnel training and management, financial management, provision of equipment, and control technic is true. It is evidenced by the declining percentage of the total area within the forest boundaries that has been burned over annually by 5-year averages since 1910. The percentage for each period was as follows:

Period	Per cent
1910–1914	0.75
1915–1919	.60
1920–1924	.29
1925–1928	.28

The last percentage shown above covers only four years, since the 1929 record is not yet completed; the years are calendar, not fiscal, years. It is probable that when this year's losses

are fully known and averaged in they will raise the last percentage. The successive percentages suggest an approach to a stationary condition, beyond which little further improvement can be looked for unless the limiting factors that are slowing down progress can be discovered and removed.

Efficient fire control means having as few fires as possible, and holding those as small as possible. Much more must be done to prevent fires, by such measures as roadside clearing, informing and cautioning the public, and enforcing safety laws and restrictions. Many man-caused fires will start, however, even when prevention effort is greatly intensified; and there will always be the lightning fires. Ability to hold within the smallest possible limits each fire that does get under way is, therefore, fundamental for satisfactory protection.

Just as in a city, prompt discovery of each fire, speedy transmittal of the report of its location, instant starting of properly equipped and properly trained fire fighters for the scene, and swift movement in transit are of first importance. Much of the protective effort of the Forest Service has gone into providing for these essentials. They necessitate, of course, not only organization but also such accessories as lookout stations, telephone communication systems, roads, and apparatus. The inadequacy of the present equipment of the Forest Service with various of these accessories is brought out later. But however fast the action, when fires spread rapidly they can not all be caught and stopped while small.

Most of the fire losses, and usually by far the greater part of the expenditure for protection, result from large fires. Although, as Table 8 showed, five-sixths of all the 1928 fires were held to less than 10 acres each, the bulk of the damage was done by the fires which covered 100 acres or more. Every such fire is made the subject of subsequent inquiry, to discover why it was not held in closer check. The conclusions established regarding California were significant in several respects.

Fires that covered more than 100 acres each were responsible for nineteen-twentieths of the area burned over. Their after-study disclosed that three-fourths of the total area was covered by fires which it is not reasonable to expect to keep below 100-acre size, with existing means. The big losses and the heaviest fire fighting expenditures in California are due to fires that start on areas of extreme inflammability. Largely these are covered with brush and grass, and largely they are outside the national-forest boundaries. Such fires spread so swiftly that suppression in their incipiency is usually impossible. For fires which have gained marked headway control during the first night becomes the logical objective. But two-thirds of the area burned in California during the 1928 season was covered by fires that were not stopped the first night, and nearly half by fires of which first-night control can not be expected without advance construction of permanent fire lines and breaks. The need for protective improvements of this character has not as yet been adequately recognized in the provisions made for the work of protection.

SEASON OF 1929

Although the fire season of 1929 started comparatively late, the intensity and area of the fires in the California, north Pacific, and northern Rocky Mountain districts bid fair to make it one of the most disastrous in recent years. In all three of the Pacific Coast States the winter precipitation was greatly below normal, and in the north Pacific Coast States the spring rains also were less than usual. Many small fires occurred in California from the first of the year to May, when the forests were becoming very dry. By the end of June large fires were burning outside the national forests, and early in June one of these entered the Lassen Forest and burned over 1,500 acres before it was brought under control. Throughout August many fires occurred in all parts of California, with generally unfavorable weather conditions, especially in the first half of the month, when winds, high temperatures, and low humidity made control very difficult. In northern California there were many incendiary fires.

Little trouble was experienced in the north Pacific Coast States until July. During the latter part of July lightning storms in a period of extreme inflammability caused serious fires, and by the middle of August, 13 large fires out of control had burned over 35,000 acres of national-forest land in Washington and Oregon. Late in August the situation was still acute, with 92,000 acres burned on the Chelan and Colville Forests along the international boundary.

In the northern Rocky Mountain district the spring and early summer were cool and showery. Late in July the rapidly drying country and frequent lightning storms brought out the fire fighters in full force. In early August extreme inflammability created a situation of extraordinary hazard. The seriousness of the situation was increased by the occurrence of fires on the public domain outside the national forests, with the necessity for assistance in men, equipment, and supplies by the Forest Service. In the extremity the local forces were recruited by calling for assistance from other national-forest districts in which the danger was not imminent.

In the second and third weeks of August the situation rapidly grew worse. August 23 was reported as one of the worst fire days in the history of the district, rivaling the disastrous August 22 and 23 of 1910. Heavy gales whipped up the fires on six of the burning forests and caused new fires on three other forests to spread over an immense area in a few hours. One fire burning near Kalispell, Mont., on Forest Service and protective-association lands and on the Glacier National Park had covered on that day approximately 75,000 acres with extensive losses of improvements and property.

During July a very serious fire situation developed on the Superior National Forest, in northern Minnesota. Heat and low humidity had created extraordinary conditions; many of the swamps had become completely dry, the humus in the timber was "powder dry," and conditions generally were the worst in years. The most serious of the fires was beyond control for several days. Over 7,000 acres of national-forest lands were burned over, with a suppression cost of upward of $28,000.

From the data available as this report is closed, the expenditures for fire suppression in the 1929 season will make necessary a very large deficiency appropriation. The activity of the fire prevention and suppression forces is indicated by the fact that only 10 per cent of the fires reached the size of 10 acres.

FOREST PROTECTION BOARD

Mention has been made in previous reports of the organization, by the chief coordinator of the Bureau of the Budget, of a protection board comprising representatives of the Federal bureaus responsible for the administration and protection of forest lands. The regional boards organized under the central board have extended the work. A notable example was the creation of a joint board of fire review to analyze certain troublesome fires which concerned two Federal bureaus and a State forest service. Impersonal and painstaking analysis of the detailed history of individual fires, including all the measures employed in handling them, has proved a very constructive means of discovering how to improve the functioning of the national-forest protective force. The method should prove equally helpful in dealing with situations in which various Federal, State, and other agencies are concerned, and in which complete coordination of effort is essential.

The value of bringing into touch with each other the field representatives of the various Federal agencies that have to do with the protection of forest lands owned by the United States is obvious. A means is provided to enable them to correlate their efforts, to work out as joint problems the procedures desirable where cooperation can be advantageously employed, and to profit by interchanging information, pooling experience, and borrowing from one another methods of proved worth. Along with the improvement of field performance and the promotion of economy in the use of funds which the functioning of the forest-protection board is bringing about, the board is also undertaking a very important work of correlation through the study of the relative needs of the various classes of Federal properties that have to be protected, and the formulation of protective plans based on a broad-guage survey of the entire task of the Government in this field, seen as a whole. The board functions, of course, as a creation and subordinate agency of the Bureau of the Budget, to which it reports. It is thus in position to be of great service in constructive fiscal planning in connection with its task of coordination.

AIR PATROL

From 1919 to 1927 use was made of aircraft for the protection of the national forests under cooperative arrangements between the Army Air Corps and the Forest Service. During the latter part of this period the Army Air Corps furnished the planes, and the Forest Service employed the pilots and mechanics, using forest officers as observers. In 1918 changed conditions

made it impracticable for the War Department to continue to furnish planes, and it became necessary for the Forest Service to contract with commercial aviation agencies for such aerial patrol as fire conditions might make necessary, these agencies furnishing the planes and operating personnel and the Forest Service providing observers as before. Insufficient time has passed to determine conclusively the relative advantages or disadvantages of the new plan, but present indications are that it gives the service needed at a somewhat lower cost.

RADIO

In the report for 1928 the use of radio in connection with national-forest protection was discussed, and an outline was given of the experiments inaugurated to solve, if possible, the technical problems encountered on the national forests. This work is being carried forward as planned. By the close of the present field season it is hoped that the possibilities which radio may have for communication in mountainous timberland, in connection with fire control, will be sufficiently determined to establish whether it has any important value. If with the right combination of wave lengths, arrangement of antenna, type of battery power, and other adjustments, radio equipment can be used effectively as a supplement to the telephone systems on the national forests, the problem of obtaining the equipment will arise. To provide the national forests on which bad fire conditions make such supplementary communication facilities urgently important will require an outlay estimated at between $130,000 and $190,000.

It is impossible to provide from the present appropriations adequate equipment of proved value, and badly needed. Motor equipment, water pumps, and tank trucks are examples of the things essential in modern methods of efficient fire control, of which the supply is entirely insufficient. If the radio is to be added to the list the need for additional funds will be still greater.

USE OF MACHINERY

In common with the industrial world the Forest Service is seeking to replace hand labor or multiply its productivity by the use of machinery and mechanical processes. It is possible to record developments of considerable importance.

In the report of the fiscal year 1927, mention was made of the use of a heavy draft animal and a special kind of plow to speed up the trenching operation which is necessary in most regions in stopping the spread of forest fires. Since that time a machine tool used in road building has been modified to answer the same purpose. When drawn by a light tractor, it has considerably more speed than a horse and plow, is much steadier, and is of course untiring. In the type of country to which it is adapted it is rated as the equivalent of from 50 to 100 men working with ordinary hand tools.

In the Pacific Northwest the size and number of snags on old burns and cut-over areas makes them an outstanding problem in forest protection. To stop the spread of a forest fire or to put a cut-over area in proper condition for protection, the snags need to be felled. It is almost impossible to stop a fire on an area covered by such standing snags because of the way they scatter fire over the heads of the fire fighters. To fell them by hand sawing is slow and costly. Holes bored in the base of a snag make it possible to fall it by blasting or burning, but hand boring is too expensive. Boring by machinery has been proved practicable, and the method is already employed in a small way. Electric power from portable generators drives portable electric drills which bore the holes. Wider use of the method is expected to have far-reaching results.

Another opportunity for the development of the use of machinery is in connection with the construction of firebreaks and the opening of trails in rough country. In California the heaviest type of logging tractor in combination with the heaviest type of road grader or special forms of drags is being used to crush and shove aside heavy growths of brush, which must be got out of the way in road building or firebreak construction. On ground which was not excessively rough a firebreak 40 feet wide was thus cleared at a cost of $40 per mile, exclusive of depreciation on the machinery, as against a cost of $450 per mile by the usual hand labor. In another case a firebreak 50 feet wide cost approximately $125 per mile, and a simple motor road of the type needed for fire control was built in connection with it for $75. Where the presence of rock made the use of the usual grader impossible a form of heavy drag was devised to follow the tractor, which could itself dodge the worst of the

rocks, and a firebreak was constructed in a critical area at approximately one-tenth the cost of handwork. Unfortunately much of the ground where firebreaks are most urgently needed is so rough and steep that no machinery yet developed can be used. Nevertheless, there is a large field for the use of the machinery that has been already successfully employed. In many parts of the country it will make practicable the construction of protective works the cost of which would otherwise be prohibitive. In the roadside clearing which must be done eventually as a means of fireproofing forests and watersheds such machinery will play an increasingly important part. Similar efforts to develop new appliances and machinery is going on in every national-forest activity which seems to offer opportunity for the use of mechanical devices to the advantage of the work.

Substantial progress has continued in using water in fire suppression, through the employment of portable power pumps and hand-power backpack pumps. A further significant advance has been made in this direction in the Pacific Northwest and in California through the development of tank trucks. In one of these experimental types a separate power unit capable of cross-country travel has made it possible to place water on fires which occurred some distance from roads in an unwatered country. The other types are a single unit designed to reach fires starting along roads. All have proved their worth by enabling suppression forces to catch fires which otherwise, by hand labor alone, would have become large. The always-difficult problem of mopping up fires has been greatly simplified and the process much shortened. Existing appropriations make inadequate provision for the purchase of such very necessary equipment.

PROTECTIVE IMPROVEMENTS

That fire losses have been greatly increased by the lack of protective improvements has long been recognized. The fire seasons of 1927 and 1928 demonstrated this still more emphatically. Last winter the Forest Service completed an estimate of the protective improvements needed immediately on the national forests. This estimate is tabulated in Table 9. It does not include the protective improvements required for a special situation on the four national forests in southern California, but does include provision for the considerable new areas added to the national forests by purchase and by exchange.

To protect the forests effectively the regular force of fire guards must be augmented in times of extreme fire danger by a large force of emergency guards. These guards should be on duty at assigned points in advance of the actual outbreak of fires. If telephone lines, lookout houses, and other necessary structures are not available the guards are of relatively little use. Hardly a beginning has been made toward equipping the forests with a system of emergency fire improvements.

The estimate includes some provision for a system of firebreaks and roadside clearing outside of southern California. The need in this direction was made very clear by the severe losses in 1927 and 1928.

TABLE 9.—*Protective improvements needed on the national forests*

Class of improvement	Cost of additions and replacement of obsolete and worn-out improvements	New improvements needed			Total cost
		Miles or number	Unit cost	Cost of new construction	
Telephone lines	$305,000	12,600	$90	$1,134,000	$1,439,000
Firebreaks and roadside clearing	6,400	6,140	130	798,200	804,600
Lookout houses	36,000	480	700	336,000	372,000
Towers and observatories	60,200	305	800	244,000	304,200
Cabins for firemen	44,000	1,500	320	480,000	524,000
Barns	4,500	450	230	103,500	108,000
Warehouses, tool storage, work shops, etc	29,500	850	120	102,000	131,500
Fences	29,000	700	160	112,000	141,000
Water development	3,500	640	110	70,400	73,900
Pasture development		180	100	18,000	18,000
Total	518,100			3,398,100	3,916,200

The estimate does not include roads and trails, which are of course essential in protection. That speed and effectiveness in fire suppression are directly controlled by the adequacy of the road and trail system has been demonstrated with increasing force in recent years. The present annual appropriation for minor roads and trails is $3,000,000. At present costs, and at that rate of appropriation, the needed work of this character which is now planned will be completed 37 years hence. Meanwhile losses will be mounting through the destruction of merchantable timber and of scenic and recreational values; through flood damage, the impaired value of watersheds, and the conversion of timberlands into unproductive wastes.

The tabulated statement does not include range improvements or the structures and developments which are classed as administrative improvements, although both have an important relation to forest protection as well as to the utilization of forage and the general conduct of business.

PROTECTION FROM INSECTS AND TREE DISEASES

Tree-killing insects are always at work in the forests, but ordinarily not in such numbers as to necessitate special protective measures. It is becoming apparent, however, that greater attention should be paid to incipient infestations than has been given in the past; they should be regarded as comparable to small fires which should be discovered and attacked before they have time to spread widely; and the forests should be patrolled for insect infestations with sufficient intensiveness to head off epidemics.

Bark beetles are particularly destructive to our coniferous forests. When circumstances happen to favor a rapid development of the broods, extensive destruction of timber takes place over a widening area unless vigorous control measures are undertaken. Forest fires are often followed by beetle outbreaks, due to the enfeebled condition of the trees, which lowers their powers of resistance. In turn, the great quantities of dead timber left after a severe insect epidemic add to the fire menace.

Last year the most serious insect epidemics were in Montana and Idaho. In spite of the fact that 60,000 acres were treated in the spring of 1928, the infestation in lodgepole pine on the Beaverhead National Forest, in Montana, continued to spread so rapidly that its control by direct attack without very great and, it was believed, unjustified expenditures became evidently impossible. The present control measures, therefore, consist of establishing zones of control based upon natural open barriers and maintaining an intensive patrol in the timber outside of these zones, to pick up any infestations which may occur as the result of beetles crossing the barriers. The general drift of the infestation is south and east, and the present plan is designed to keep the beetles from reaching the valuable timber stands on the Madison National Forest and the Yellowstone National Park.

Another beetle infestation has been developing in lodgepole pine west and south of the Yellowstone National Park, in the Targhee, Wyoming, Cache, and Caribou National Forests. Intensive control operations were inaugurated in 1928 and are continuing. Since it was possible to start the control before the infestations got very much headway it is believed this attack has been checked.

In the north Idaho white-pine region there has been a growing infestation in white-pine stands on the Coeur d'Alene, Kootenai, and Kaniksu Forests. Control projects have been under way on the Coeur d'Alene and Kootenai Forests for the past two years, with good progress, but recent surveys show that new centers of infestation are building up. Quick action and considerable expenditures of control funds will be required if the situation is to be properly handled. The infestations on the Kaniksu are largely the result of the serious fires on that forest in 1926, and are so general in distribution that such control as is undertaken will have to be largely through timber sales.

On the Targhee National Forest, in Idaho, a very threatening bark-beetle epidemic of extensive proportions is being attacked, apparently with success, by a method developed locally by the forest officers. The trunks of infested trees are sprayed with oil and a match is applied. The fire runs up the trunks and kills the beetles in the bark of the standing tree. This method is far cheaper and more expeditious than felling and barking the trees. The cost has averaged about 50 cents per tree treated.

On the Shoshone Forest, in Wyoming, the spruce bud worm has heavily infested the Douglas fir timber in Cody Canyon, leading into the Yellowstone National Park. This insect is a defoliator, and if not controlled in one or two seasons will kill the trees by

stripping them of their foliage. Some experimental control work was done this spring which indicated that the outbreak could probably be stopped if sufficient funds and proper equipment could be made available. The method of controlling these insects is by dusting or spraying the foliage with some form of poison. Since the trees are very tall, special apparatus is required to reach the tops. The work is accomplished by spraying with high-pressure spraying machines or by dusting from airplanes.

In Oregon and California the situation is markedly improved. For a number of years a very severe epidemic has been in progress on both public and private lands on the Modoc Forest, in California. The timber affected was so inaccessible and the infestation so general that it was not until last year, when a railroad was definitely assured through the area, that control measures became practicable. As the result of the contemplated railroad a sale of Government timber was made to an owner of a large acreage of infested private timber, which provided for the immediate logging of the infested trees from 15,000 acres of Government and private lands before the emergence of the beetles last spring. Partly in consequence of these control measures, partly through a decline in the infestation from natural causes, the present indications are that the infestation is now well in hand and further losses of timber should be small.

The treatment of an area of lodgepole pine adjacent to the Crater Lake National Park, to supplement control work done by the National Park Service, was continued. The present indications are that the spread of the insects has been checked. In and adjacent to the Fremont National Forest control work was continued in cooperation with timberland owners, and here also the outlook is more encouraging.

The technical methods followed in each case were recommended by the Bureau of Entomology. The best of cooperation is received from this bureau, which has been of invaluable assistance to the Forest Service in training its officers to recognize dangerous conditions when they are encountered, as well as in prescribing the action necessary for control.

The white-pine blister rust is advancing in the western forests and constitutes a menace to the very valuable white-pine stands of a character so grave as to make the immediate inauguration and determined prosecution of protective measures a matter of almost incalculable importance. In a single region, that in which the species often called Idaho white pine is the most valuable tree in the present timber stands, the future production of this tree on about 1,500,000 acres of national-forest land is at stake. For control of the disease the eradication of the native wild currants is necessary. A 20-year program of eradication has been outlined, calling for an expenditure in this region of $100,000 the first year and $200,000 annually throughout the rest of the period. The per acre cost of carrying out this program is approximately $2.70; it may, however, prove that as the work becomes well organized this cost can be materially lowered. It is estimated that the difference in value between a crop of white pine on the land and any other species that can be grown will amount to between $400 and $800 per acre. The undertaking of the control program must await the making of the necessary appropriation for the work.

TIMBER

The timber cut exceeded that of any previous year, with a total under sale contracts and land exchanges together of more than 1,500,000,000 board feet. The cash receipts exceeded $4,000,000, for the first time, and increased $783,000 over the previous fiscal year. All national-forest districts except Alaska contributed to the increase.

This expansion was not due to any change in policy. The well-established policy is not to press timber on the market unless it becomes necessary to salvage timber which is deteriorating in consequence of fires, insect attacks, or other causes. The increase was due primarily to demands resulting from the liquidation of private stumpage. Operators who had exhausted their own stumpage extended their operations by purchases of Government timber, thus preserving their own goodwill and going-concern assets, utilizing for a longer period their fixed investments in mills and transportation, and helping to maintain communities. Other operators were preparing to cut private stumpage so intermingled with that of the Government that there would be a great economic waste in logging one without the other. In

either case it is sound public policy to make national-forest timber available.

The stabilization of industries and communities is a recognized objective in national-forest timber management. When established enterprises need timber to continue in operation, if it can be supplied from the national forests without overcutting them—that is, without taking the timber off faster than the management unit, or "working circle," will grow more—it is made available at a fair price. The corollary of sustained yield is sustained industries.

In part, the increased use of national-forest timber is a result of the increasing efficiency of logging and lumber manufacturing. New types of machines and improvements in old types have made it possible to operate on areas previously considered inaccessible because of the high cost of logging them. The extensive replacement of the steam donkey engine by internal-combustion engine tractors, in the California pine region especially, has lessened logging costs and also has reduced the danger of fire. Each improvement in logging or milling efficiency adds to the area of timber in which logging is practicable, and thus gives more owners the desired opportunity to liquidate their holdings. If these holdings are within or adjacent to a national forest, pressure for the purchase of Government timber inevitably results, sooner or later.

Another factor in the increased cut of last year was the at least partial recovery of the lumber industry from its serious depression in the calendar year 1927. Such periods of depression tend to obscure the gradual but steady development of timber operations on the national forests. The increases in volumes cut and receipts during successive years are irregular. Viewed over a period of years, however, the timber business is manifestly advancing, through an average increase of between 8 and 10 per cent in the annual cut, toward the full sustained yield.

This moderate increase, under the policy of not aggressively forcing timber on the market, has as yet brought the cut up to its ultimate proportions in only a few isolated localities. For the national forests west of the Great Plains, exclusive of Alaska, the cut during the calendar year 1928 was the equivalent of only 17½ board-feet per acre of timberland (which does not include such land as the pinon-juniper woodland of the Southwest), while for the eastern forests the cut was the equivalent of only 10 board-feet per acre. In both cases all forms of material taken out, whether saw logs or not, are included. When all the land is covered with growing stands the national forests can provide a permanently sustained annual cut at least six times the present. Taken by States, the national forests of South Dakota, with a present cut of 43 board-feet per acre of timberland, are probably nearest their sustained yield, and those of New Mexico, with a 1928 cut of less than 5 board-feet per acre of timberland, are the lowest in the West.

The eastern national forests, made up as most of them are principally of lands purchased after the merchantable stand of timber had been lumbered, afford at present relatively limited opportunities for timber sales. It is gratifying to record that their timber business last year showed an increase of about 50 per cent in receipts. Among the sources of this increase were the first winter's operations on a 15-year sale, chiefly of pulpwood, on the White Mountain National Forest in New Hampshire, and a sale of shortleaf pine saw timber on the Ouachita National Forest, Ark., to a company owning intermingled and adjacent timber. At the close of the year advertisement was being made of a sale of pulpwood and saw timber amounting to the equivalent of 196,000,000 board feet on the Superior National Forest, Minn. These national forests east of the Great Plains will contribute more and more as time goes on and as their stock of growing timber is built up and improved through skillful management toward meeting the wood needs of the industries and population of the regions in which they are located.

Tables 10, 11, and 12 present in detail the timber-sale business of the calendar year 1928.

TABLE 10.—*Quantity and value of national-forest timber sold, by States, calendar year 1928*

State	Quantity sold			Value		
	Commercial sales	Cost sales	Total	Commercial sales	Cost sales	Total
	Board feet	*Board feet*	*Board feet*	*Dollars*	*Dollars*	*Dollars*
Alabama	70,000		70,000	157		157
Alaska	17,750,000		17,750,000	29,530		29,530
Arizona	166,937,000	461,000	167,398,000	377,671	465	378,136
Arkansas	15,288,000	172,000	15,460,000	86,329	173	86,502
California	668,719,000	1,810,000	670,529,000	1,753,363	1,214	1,754,577
Colorado	109,777,000	933,000	110,710,000	230,466	942	231,408
Florida	2,161,000		2,161,000	5,264		5,264
Idaho	82,102,000	4,615,000	86,717,000	206,451	4,251	210,702
Kentucky	5,000		5,000	22		22
Michigan	4,150,000		4,150,000	8,317		8,317
Minnesota	3,754,000		3,754,000	14,564		14,564
Montana	31,261,000	4,625,000	35,886,000	70,644	4,863	75,507
Nevada	1,324,000	236,000	1,560,000	1,753	200	1,953
New Hampshire	142,043,000		142,043,000	1,000,544		1,000,544
New Mexico	18,786,000	634,000	19,420,000	43,196	678	43,874
North Carolina	17,363,000		17,363,000	40,723		40,723
Oregon	999,109,000	3,076,000	1,002,185,000	2,956,690	2,013	2,958,703
Pennsylvania	2,015,000		2,015,000	7,088		7,088
South Dakota	37,291,000	350,000	37,641,000	170,604	368	170,972
Tennessee	8,268,000	109,000	8,377,000	11,203	117	11,320
Utah	59,457,000	1,130,000	60,587,000	126,688	1,189	127,877
Virginia	21,349,000	6,000	21,355,000	37,415	8	37,423
Washington	184,735,000	214,000	184,949,000	388,130	137	388,267
West Virginia	1,122,000		1,122,000	3,645		3,645
Wyoming	75,160,000	1,549,000	76,709,000	195,190	1,402	196,592
Total, 1928	2,669,996,000	19,920,000	2,689,916,000	7,765,647	18,020	[1] 7,783,667
Total, 1927	626,175,000	16,523,000	642,698,000	1,562,382	14,885	[2] 1,557,267

[1] In addition, minor products not convertible into board feet were sold, valued at $22,629.
[2] In addition, minor products not convertible into board feet were sold, valued at $59,368.

TABLE 11.—*Quantity and value of national-forest timber cut under sales, by States, calendar year 1928*

State	Quantity cut			Value		
	Commercial sales	Cost sales	Total	Commercial sales	Cost sales	Total
	Board feet	*Board feet*	*Board feet*	*Dollars*	*Dollars*	*Dollars*
Alabama	101,000		101,000	237		237
Alaska	40,246,000		40,246,000	62,893		62,893
Arizona	66,615,000	379,000	66,994,000	171,973	412	172,385
Arkansas	5,130,000	234,000	5,364,000	31,485	234	31,719
California	291,161,000	1,776,000	292,937,000	906,189	1,114	907,303
Colorado	48,877,000	1,128,000	50,005,000	129,723	1,133	130,856
Florida	1,773,000		1,773,000	5,610		5,610
Idaho	150,720,000	3,657,000	154,377,000	565,322	3,423	568,745
Kentucky	9,000		9,000	127		127
Michigan	4,216,000		4,216,000	7,427		7,427
Minnesota	6,238,000		6,238,000	25,482		25,482
Montana	27,095,000	3,255,000	30,350,000	67,496	3,396	70,892
Nevada	1,290,000	243,000	1,533,000	1,974	228	2,202
New Hampshire	6,914,000		6,914,000	37,526		37,526
New Mexico	16,269,000	695,000	16,964,000	35,938	727	36,665
North Carolina	11,522,000		11,522,000	29,196		29,196
Oregon	258,154,000	2,519,000	260,673,000	785,207	1,604	786,811
Pennsylvania	1,344,000		1,344,000	10,503		10,503
South Dakota	34,828,000	479,000	35,307,000	127,035	521	127,556
Tennessee	12,766,000	111,000	12,877,000	16,058	123	16,181
Utah	7,881,000	1,024,000	8,905,000	15,897	1,056	16,953
Virginia	10,705,000		10,705,000	30,764	2	30,766
Washington	271,699,000	200,000	271,899,000	570,060	121	570,181
West Virginia	489,000	2,000	491,000	1,791	3	1,794
Wyoming	43,696,000	1,174,000	44,870,000	115,384	1,045	116,429
Total, 1928	1,319,738,000	16,876,000	1,336,614,000	3,751,297	15,142	[1] 3,766,439
Total, 1927	1,075,433,000	16,188,000	1,091,621,000	2,969,196	14,277	[2] 2,983,473

[1] In addition, minor products not convertible into board feet were cut, valued at $23,503
[2] In addition, minor products not convertible into board feet were cut, valued at $8,484

TABLE 12.—*Number of national-forest timber sales, classified according to amounts of sale, by States, calendar year 1928*

State	$500 or under, commercial sales	$500 or under, cost sales	Total	$501 to $1,000	$1,001 to $5,000	Over $5,000	Total
Alabama	13		13				13
Alaska	205		205	4	5		214
Arizona	914	240	1,154	3	5	3	1,165
Arkansas	44	69	113	1	1	3	118
California	547	316	863	4	17	13	897
Colorado	672	182	854	5	9	5	873
Florida	83		83				83
Idaho	925	1,543	2,468	4	12	7	2,491
Kentucky	2		2				2
Michigan	53		53	2	2		57
Minnesota	171		171	1	2	1	175
Montana	647	1,089	1,736	2	8	2	1,748
Nevada	56	94	150				150
New Hampshire	122		122			1	123
New Mexico	842	411	1,253	2	5	2	1,262
North Carolina	308		308	2	3	1	314
Oregon	558	573	1,131	1	7	9	1,148
Pennsylvania	9		9	1		1	11
South Dakota	309	70	379	1	16	7	403
Tennessee	247	51	298		1		299
Utah	286	638	924	2	3	1	930
Virginia	421	5	426	2		1	429
Washington	176	59	235	5	8	12	260
West Virginia	11		11		1		12
Wyoming	313	290	603		8	3	614
Total, 1928	7,934	5,630	13,564	42	113	72	13,791
Total, 1927	7,462	4,970	12,432	60	105	51	12,648

PLANTING

Forest lands that have been badly burned, or logged by some of the more destructive methods, can be made to grow new crops of timber only by planting. The ability of the forest to perpetuate itself has been lost. There are more than 2,100,000 acres of such lands within the national forests. Only a small beginning has been made on the job of planting them. The main effort of the Forest Service has been to prevent the increase of this area through forest fires; and many millions of acres of land with scattered seed trees have had natural young stands established on them. But the 2,100,000 acres lack seed trees, and the natural return of the forest through gradual seeding and advance from the borders is exceedingly slow. The restoration of these lands to productivity is an urgent public need.

Nearly 50 per cent more land was planted in the national forests in 1928 than in any previous year during the past decade. In part this was due to the patriotic interest of organizations which, realizing that the rate of progress in national-forest planting work in their regions was wholly inadequate, voluntarily provided funds for increasing it. In Michigan and in Washington these contributions enabled the Forest Service to plant nearly 5,000 acres more than would otherwise have been possible. The $60,000 increase in the appropriation for planting also added substantially to the area planted.

By a special act, $20,000 of the planting appropriation was made available for the purchase of land to establish or enlarge nurseries. A nursery site was purchased and a nursery established near Susanville, Calif., and land was obtained for urgently needed enlargements of the nurseries at East Tawas, Mich., and Halsey, Nebr. To enlarge the Monument nursery, on the Pike National Forest, Colo., suit was filed to condemn land the direct purchase of which proved to be impossible because of technical flaws in the offered title. A nursery was also established on the Medicine Bow National Forest, Wyo. Nursery establishment or enlargement is the first step in materially enlarged planting activities.

The action taken in Colorado and Wyoming has been taken with a view to planting extensive old burns on the watersheds from which the cities of

Denver and Cheyenne, respectively, secure their municipal supplies. The enlarged nursery at East Tawas, Mich., will provide stock for planting 10,000 acres annually of the denuded lands on the Huron National Forest. The enlargement at Halsey, Nebr., was chiefly to further the cooperative production of nursery stock for distribution by the State under the terms of section 4 of the Clarke-McNary Act. The California nursery will supply stock for the planting of burns on highly productive pine lands on the national forests in that State. When these new or enlarged nurseries are producing trees of the necessary kinds and sizes, the area which can be planted annually under the existing appropriation will be between 20,000 and 25,000 acres. At this rate the planting of the 2,100,000 acres of denuded timberland now within the national forests can be completed in about 100 years. But the purchases of new land by the National Forest Reservation Commission is constantly adding to the acreage. Because of their location with reference to industries and population the prompt restoration to productivity of many of these acquired areas is even more important than the reforestation of some of the burns in the western national forests. The National Forest Reservation Commission has already approved for purchase a total of over 142,069 acres in the Upper Peninsula of Michigan and in northern Wisconsin. Of this at least 70,000 acres should be planted. Similarly, in the Allegheny National Forest in Pennsylvania there are 60,000 acres of highly productive land which at present is growing only tree weeds and bushes, but which should be producing spruce or other valuable pulp or timber species. The enlargement of the planting program of the Forest Service to bring it into balance with other activities and with the purchase program contemplated by the Clarke-McNary Act is urgent.

TABLE 13.—*Planting and sowing on national forests, by States, calendar year 1928*

State	Area planted	Area sown	Total
	Acres	*Acres*	*Acres*
Michigan	11,417.85		11,417.85
Washington	1,416.00		1,416.00
Idaho	1,343.00		1,343.00
Nebraska	1,302.70		1,302.70
Colorado	1,237.12	2.00	1,239.12
Minnesota	953.50		953.50
Oregon	664.00		664.00
Montana	167.48		167.48
Wyoming	103.52		103.52
West Virginia	88.10		88.10
North Carolina	45.00	2.00	47.00
Pennsylvania	38.40		38.40
California	34.74		34.74
Virginia	11.30		11.30
Tennessee		8.25	8.25
Oklahoma	2.50		2.50
Total	18,825.21	12.25	18,837.46

RANGE

GENERAL RANGE AND LIVESTOCK CONDITIONS

Practically throughout the western range country the year was abnormal from the standpoint of the livestock man. As a rule the winter of 1927–28 provided adequate moisture, but cold spring or hot and dry summer weather curtailed the production of forage nearly everywhere. Nevertheless, livestock came through the year in fair to excellent condition; but in many localities it was necessary to take the animals off the range earlier than usual. Their good condition in spite of the unfavorable growing season was partly due to more conservative stocking, better handling, and the removal of trespassing wild horses.

The winter of 1928–29 was very severe in the central Rocky Mountain region. Heavy snows and cold weather caused severe losses and increased the wintering costs. On the other hand, the heavy precipitation greatly enhanced the prospects for the spring and summer. Excellent prices in 1928 and the early part of 1929 more than offset in most localities the rather adverse physical conditions. Except for a short period in the fall of 1928 cattle prices increased steadily over those of previous years, and wool and mutton remained fairly high. Since weather and market conditions combined to cause heavy sales of cattle of all classes, the depleted condition of the breeding herds was not materially bettered.

The very serious financial straits in which a large percentage of the western stockmen were involved for a considerable period have been remarkably improved during the last two years, and the livestock business is approach-

ing a state of normal prosperity. If the present economic conditions continue for two or three years longer the losses suffered by the industry will have been largely recovered.

RANGE USE

The use made of the national-forest ranges in the calendar year 1928 is shown in Table 14.

TABLE 14.—*Grazing permits issued and number of stock grazed on the national forests, by States, calendar year 1928*

State	Cattle, horses, and swine				Sheep and goats		
	Permits issued	Stock grazed			Permits issued	Stock grazed	
		Cattle	Horses	Swine		Sheep	Goats
Alabama	3	34	2				
Arizona	1,085	187,463	2,231	460	120	288,636	1,766
Arkansas	20	202					
California	1,872	149,481	5,837	212	365	441,370	2,752
Colorado	2,979	277,814	5,081	60	881	1,050,609	421
Florida	4	152			4	1,034	
Idaho	2,844	119,525	8,973		1,012	1,335,911	250
Montana	1,942	119,943	9,564		481	602,113	90
Nebraska	36	11,265	590				
Nevada	364	51,085	2,284		139	316,538	
New Hampshire	20	129	35				
New Mexico	1,907	81,065	3,446	168	294	227,651	10,491
North Carolina	56	278	13	131	16	240	
Oklahoma	50	2,489	75				
Oregon	1,032	84,165	3,404		470	648,117	200
South Dakota	526	22,399	1,035		25	20,180	
Tennessee	23	183	2		6	224	
Utah	4,016	111,253	4,302	175	2,157	757,890	1,100
Virginia	51	539	12		4	103	
Washington	359	11,026	506		135	161,513	
West Virginia	11	100	4		38	909	
Wyoming	767	105,313	4,560		310	656,383	
Total, 1928	19,967	1,335,903	51,956	1,206	6,457	6,509,421	17,070
Total, 1927	20,871	1,403,192	55,629	1,002	6,129	6,376,838	18,046

The decline in 1928 from the number of cattle and horse permits and cattle and horses grazed in 1927 continues a trend that has been in evidence since 1919. In the 10-year period permits have fallen from 32,528 to 19,967, or 39 per cent, and the number of cattle from 2,135,527 to 1,335,903, or 37 per cent. On the other hand, for sheep a low point was reached in 1925. In the seven years 1919–1925 the number of permits declined from 6,624 to 5,835, or 12 per cent; the number of sheep, from 7,935,174 to 6,162,263, or 22 per cent. In 1928 11 per cent more permits were issued than in 1925, but 2.5 per cent fewer than in 1919. The number of sheep in 1928 was 5.6 per cent greater than in 1925, but 18 per cent less than 10 years ago.

These changes in grazing use have been primarily due to (1) the overburdening of many forest ranges during the war, which necessitated marked reductions to allow them to recuperate; (2) the postwar depression, with its forced retrenchment and liquidation; (3) the more rapid recovery in the sheep industry, with its consequent incentive for cattle permittees to transfer to the sheep business; (4) the recent heavy demand and high prices for cattle as well as sheep, which have influenced cattlemen, particularly, to sell heavily rather than replenish their herds; and (5) the more conservative stocking of the ranges to protect more adequately their forest, forage, and watershed values.

The reports of local forest officers have emphasized the smallness of losses from shortage of feed. This good showing demonstrates the importance of stocking conservatively enough to have adequate forage during bad periods.

Stockmen would generally rather have adequate feed for a restricted number of livestock than run large herds with no assurance of adequate forage during drouth periods or severe winters. The greatly increased calf

and lamb production and the better rate of growth that accompany abundant feed are convincing proof that conservative stocking benefits the livestock operator as well as the range, the forest, and the watershed.

STABILIZATION OF RANGE USE

With the return of prosperity in the livestock industry the demand for forest range grows greater. The readily available range that can be economically used has long since been fully allotted. To provide for new applicants, the larger permittees have been cut down as far in many cases as it is practicable to go. The increased investments in dependent ranch properties and the increased values of livestock enterprises make reductions in the grazing permits used in connection with these properties very doubtful public policy. In many communities distribution has gone so far that the forests have been closed to new applicants.

Some of the larger permittees have urged that the policy of closing national forests to new applicants be widely applied and that the existing permits be maintained at approximately their present size. This demand clashes with the demand from outside stockmen for a share in the use of the ranges. It is firmly believed that under no circumstances should vested rights be established which would prevent reasonable adjustments to admit qualified applicants, or which would interfere with the full coordination of all the forest uses. On the other hand, reductions below the economic herd limit would not, it is believed, accord with sound public policy. By economic herd limit is meant the number below which the operator can not reduce and maintain a reasonably profitable enterprise.

The 10-year term permits issued in accordance with the policy of October, 1925, go as far in stabilizing the use of the range as is considered justifiable. These permits specify the number of stock which may be grazed during the period of the contract, subject to a reduction of not more than 10 per cent for distribution to other range users or qualified applicants, but subject to protection reductions at any time and in any amount necessary to safeguard the range and other forest resources. Term permits cover 47½ per cent of the cattle and 61 per cent of the sheep grazing on the national forests. Much more stock might graze under term permits, but the owners feel their tenure is sufficiently secure under annual permits and do not care to apply for term permits. The stability of range use during the last 20 years is fairly indicated in Table 15.

TABLE 15.—*Number of permits and number of stock grazed in the national forests of the six western districts in 1909 and in 1928*

Class of stock	Permits	Stock	Average per permit	Area in national forests	
				Total	Usable
Cattle, horses, and swine:	*Number*	*Number*	*Number*	*Acres*	*Acres*
1909	22,163	1,585,905	72	161,534,792	[1] 101,212,000
1928	19,779	1,387,249	70	132,442,081	83,320,523
Sheep and goats:					
1909	5,074	7,819,594	1,541	----------	----------
1928	6,389	6,523,981	1,031	----------	----------

[1] Area estimated.

The average number of cattle per permit is approximately what it was 20 years ago (72 head in 1909 and 70 head in 1928), but the average number of sheep has decreased from 1,541 to 1,021 head, a decline of 34 per cent. This decline is considered a healthy development in view of the fact that the average permit is still above the economic herd limit. Economic conditions largely account for the change. The sheep business in the West has been undergoing a modification. The great increase in the number of farm flocks has resulted in a larger number of owners, each with fewer and better-cared-for sheep. The larger operators have had to reduce their herds because of high prices of winter feed and the decrease in productivity and in acreage

of spring, fall, and winter range. With these changes in economic conditions distribution must keep pace.

While the total number of cattle, horses, and swine, and of sheep and goats was less in 1928 than in 1909, the usable area in 1928 was less. In fact the use in 1928 was more intensive than in 1909, for reduced to a cow basis (that is, using the accepted ratio of 5 sheep as the grazing equivalent of 1 cow) the average area per head of stock was 32 acres in 1909 as against 31 acres in 1928.

CHANGES IN CLASS OF STOCK

The demand for additional sheep range and the willingness of sheepmen to pay high prices for ranches and improvements used in connection with cattle permits have materially cut into some former cattle range.

The Forest Service has been urged not to allow cattle permits to be converted to sheep permits. The service position has been uniformly that the suitability of the range for the class of stock applied for and the real economic effects upon the established industries should be the governing considerations. Under this policy relatively few cases have arisen in which it was necessary to disapprove applications for changes that were administratively feasible. On the other hand, the Forest Service has felt justified in discouraging demands resulting from temporary economic conditions which if responded to would seriously affect the stability of the local livestock industry.

RANGE MANAGEMENT

The increasing demand for grazing privileges makes necessary increasing attention to the proper management of the forage resource. To this end, range-management plans are being worked out comprehensively. They analyze the grazing and related problems of each range unit, set up the management objectives, and specify the manner of use called for to attain the desired objectives. They determine the class and numbers of stock that the range can carry, the grazing season, and the distribution necessary to utilize the forage evenly. Their object is to secure the greatest use of the forage resource that is consistent with its conservation and coordination with other forest resources. They embody the best practices that have been developed by experiment and test. They incorporate the knowledge obtained by research regarding the stage of development at which the plants on each range may be safely grazed, the measures necessary to allow depleted ranges to recuperate, the best methods of developing water, the best salting practices, successful means of eradicating poisonous plants, the control of livestock diseases and of range-destroying rodents, and like matters.

Management plans have now been prepared for approximately 70 per cent of the range units on the national forests. Definite provision is made in each forest officer's schedule of work for carrying out the prescribed measures. Many instances of the resulting benefits could be cited. One forest supervisor reports that by doubling the number of salt grounds, opening up parks and trails, and reducing horse trespass the carrying capacity of one division of his forest was increased 25 per cent, with an improvement both as to the grade and the condition of the stock grazed. On another range the construction of trails and opening up of parks made it possible to provide range for two bands of sheep in place of one. In a third case the carrying capacity of a range was increased from 850 to 1,100 head through the construction of drift fences, posting additional salt grounds, and putting into effect a rotation system of grazing.

LOSSES OF LIVESTOCK

The economic waste represented by losses of livestock due to poisonous plants, predatory animals, and other causes is of increasing importance as the demand for range grows in intensity. Game birds and animals also are destroyed. The domestic livestock losses in 1928 are shown in Table 16.

TABLE 16.—*Livestock losses on national forests, 1928*

District	From poisonous plants		From predatory animals, disease, and other causes		Total	
	Cattle and horses	Sheep and goats	Cattle and horses	Sheep and goats	Cattle and horses	Sheep and goats
1	250	3,346	632	13,099	882	16,445
2	2,468	3,849	2,085	21,191	4,553	25,040
3	653	1,161	4,821	4,677	5,474	5,838
4	2,232	9,637	1,505	43,085	3,737	52,722
5	431	1,682	859	9,070	1,290	10,752
6	181	3,003	543	13,218	724	16,221
Total	6,215	22,678	10,445	104,340	16,660	127,018

To the close of the calendar year 1928, approximately 12,500 acres of poisonous plants had been eradicated, at a cost of $59,753. Control measures were concentrated upon poisonous larkspurs (*Delphinium* spp.), which do by far the greatest harm to cattle. There remain approximately 373,000 acres needing treatment. A specific example will serve to illustrate the work and its benefits. On the Gunnison National Forest, in Colorado, 7,165 acres of range had become infested with poisonous larkspur when grubbing was undertaken. There has been grubbed to date a total of 1,716 acres, at a cost of $5,728. Before control measures were undertaken the average number of cattle lost annually from larkspur was 127 head, valued at $6,350. The number lost last year was 64 head, valued at $3,200, or a saving of approximately $3,150 annually through the improved condition of the range.

While poisonous plants are widely distributed, severe stock losses are usually caused within limited sites where the plants find especially favorable conditions for their growth in relatively large quantity. This makes control measures practicable at a cost that is soon more than offset by the livestock saved and by the increased carrying capacity of the range made available. The Bureau of Animal Industry at its experiment station near Salina, Utah, is doing splendid work in determining the toxic properties of range plants and in developing remedial measures for treating animals poisoned. The Forest Service has the responsibility for developing and applying control measures on the range, which the Government as landowner should bring into fully productive condition.

The losses among domestic livestock on the national forests from predatory animals in 1928 represented a value of $1,739,765. The economic value of game birds and animals destroyed was also great. The Bureau of Biological Survey develops and applies methods to destroy predatory animals on Federal lands, and in cooperation with interested agencies is extending this work to State and private lands. The economic importance of the work calls for enlarging it greatly. An urgent obligation rests upon the Federal Government to reduce the losses suffered from such causes by the stockmen, who are now paying over $1,700,000 a year for use of the national-forest ranges.

RANGE IMPROVEMENTS

To control grazing satisfactorily, so as to obtain uniform and proper utilization of the forage, adequate range improvements are required. Often boundary fences are the only practical means of eliminating trespass and keeping stock within allotments. Approximately 10,728 miles of boundary and drift fences have been constructed. For the last three years all of the Federal improvement funds available have been concentrated in the southwestern forests, where the relatively smooth topography makes fenced control most necessary. About 1,430 miles of fences have thus been constructed. The fences still needed approximate 45 per cent of the present mileage, but the program has progressed far enough to demonstrate how much better regulation of the range use they make possible. In many instances impending heavy reductions in the number of livestock to check damage to forage and timber growth have been avoided, and the cost of handling stock has been materially reduced.

The situation with respect to range improvements is shown in Table 17.

TABLE 17.—*Range improvements constructed on national forests to December 31, 1928*

Item	National-forest district						Total
	1	2	3	4	5	6	
Boundary and drift fences.....miles	375	818	5,227	2,308	1,236	764	10,728
Water development.....number	265	374	38	737	486	386	2,286
Driveways.....miles	1,087	1,279	.....	605	44	466	3,481
Bridges.....number	25	16	17	28	7	15	108
Trails.....miles	1	.....	.....	107	26	52	186
Corrals.....number	68	77	30	47	184	131	537
Cabins.....do	36	.....	.....	3	191	77	307
Pastures.....do	15	.....	.....	8	415	1	439
Poison eradication.....acres	95	8,220	230	3,454	648	76	12,723
Salt troughs.....number	2	.....	.....	25	1,492	1,400	2,919
Cost met by stockmen.....dollars	91,685	86,110	2,199,635	116,623	332,185	142,183	2,968,421
Cost met by Federal Government .do	201,707	124,089	172,831	132,546	48,440	46,298	725,911
Total.....do	293,392	210,199	2,372,466	249,169	380,625	188,481	3,694,332
RANGE IMPROVEMENTS NEEDED							
Boundary and drift fences.....miles	270	262	2,850	371	317	736	4,806
Water development.....number	328	168	395	814	628	348	2,681
Driveways.....miles	.....	.....	.....	206	.....	99	305
Bridges.....number	27	.....	1	27	3	14	72
Trails.....miles	18	.....	90	153	20	.....	281
Corrals.....number	3	2	119	63	4	27	218
Cabins.....do	16	.....	.....	13	3	22	54
Pastures.....do	.....	.....	.....	15	42	.....	57
Poison eradication.....acres	6,175	74,163	250,971	10,985	2,827	809	345,930
Salt troughs.....number	249	.....	.....	.....	1,794	1,521	3,564
Cost to be met by stockmen.....dollars	577	34,774	380,200	137,953	43,796	73,602	670,902
Cost to Federal Government.....do	83,475	50,058	455,000	155,564	63,515	155,083	962,695
Total.....do	84,052	84,832	835,200	293,517	107,311	228,685	1,633,597

The stockmen have contributed four-fifths of the cost of the improvements hitherto constructed. In view of the benefits which they derive therefrom they will doubtless continue to construct many of those urgently needed and most valuable to them, for which Government funds are not available. The appropriation available for constructing and maintaining necessary range improvements during the fiscal year 1930 is $85,000. This will not permit of much progress toward providing the extensive system of improvements needed.

Rodents and predatory animals continue to do great damage. It is hoped that the Bureau of Biological Survey will be allotted funds with which to eradicate rodents and predatory animals on the forests as well as on other public lands. Detailed information regarding the requirements for such control is being gathered.

GRAZING TRESPASS

Table 18 indicates the development and changes that have taken place in the grazing-trespass situation during the last 15 years.

TABLE 18.—*Summary of grazing trespass, fiscal years 1914 and 1919, calendar years 1924 and 1928*

Year	Cases pending at beginning of year	New cases during year	Total cases	Increase over 1914	Cases settled								Cases pending at close of year		Amount collected per case
					Dismissed		Prosecuted		Innocent		Wilful				
	Number	*Number*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Dollars*
1914	44	145	189	.....	22	12	28	15	74	39	7	4	58	30	25
1919	112	586	698	269	64	9	77	11	320	46	94	14	143	20	75
1924	355	793	1,148	507	194	17	49	4	487	42	65	6	353	31	14
1928	183	600	783	314	70	9	3	(1)	398	51	154	20	157	20	29

(1) Less than half of 1 per cent.

The number of trespass cases increased until 1924; they have since steadily declined, but are still much higher than in 1914. This is partly because of the increased demand for range and partly because of the stricter standards of grazing administration that have gradually been applied.

The impounding regulation, adopted in 1925, has proved to be a most effective means of controlling the trespass situation and accounts in large measure for the decline in trespass cases since that time. Under this regulation forest officers are given authority to round up stock in trespass and to dispose of them if after notification the owners fail to redeem the animals. Permittees generally favor this regulation. Its application is handicapped at present by lack of provision for replacing the Forest Service funds used in rounding up the stock from the receipts derived from the sale of trespassing animals. Legislative authority to do this is highly desirable.

Under the impounding procedure the number of wild horses has been materially decreased. Only 17,625 horses were reported in 1928, as against 24,376 in 1927. If more use can be made of the impounding regulation the trespass problem can be ended within a few years.

RECREATION AND GAME

Recreational use of the national forests touched a new high point in 1928 with an estimated total of over 23,000,000 visitors, made up of 385,518 special-use permittees and guests, 1,381.595 hotel and resort guests, 1,845,693 campers, 2,937,511 picnickers, and 16,458,680 transient motorists. Use of the forests by the last-named class was, of course, incidental and casual, but entailed a heavy obligation of supervision and provision of certain camping facilities.

The number of camp grounds either newly improved or further improved during the year was 228, and the cost was $41,047. The improved camp grounds now number 1,186, but many should have new or additional equipment, and over 300 areas have not yet been provided with any facilities. The total cost of the improvements has been $282,467, of which $47,084 has been contributed, in cash, material, or labor, by private or public cooperation.

Arrangements for a more exhaustive study of the Mount Hood area, in Oregon, were made following the report of the special committee the appointment of which by the Secretary of Agriculture was mentioned a year ago. A comprehensive plan for the development of this area is being prepared by men of outstanding experience in such problems. The Mount Hood situation is merely an example of a condition which is rapidly developing in other national forests. The increased leisure of the American people, the growth of automobile and other travel and of interest in outdoor things, the changes in modes of life which accentuate the need and demand for greater recreational facilities, all tend to enlarge the social and economic importance of the national forests as public playgrounds and treasure houses of scenic, wild life, and other natural values. A large responsibility is thus created for the conservation and development of such values in proper coordination with timber production, stream-flow protection, and like forms of usefulness. Sound technical planning and direction of development is necessary to assure against unwise occupancy or modification of notable areas.

The year marked the initiation of steps to preserve permanently within the national forests specimen areas of virgin timber representing the major forest types of each region, so that there may be preserved for scientific reference and study a well-chosen series of examples of the biological balances or complexes which originally obtained. Promiscuous recreational use of such areas would alter their character, and so defeat their purpose, but to provide for the forms of recreation for which wilderness surroundings are essential a second series of much larger areas is now being selected and established, within which primitive conditions of subsistence, habitation, transportation, and environment will permanently be maintained to the fullest practicable degree.

The result of the annual estimates made by forest officers of the number of big-game animals and beavers on the national forests is presented in Table 19.

TABLE 19.—*Number of big-game animals and beavers on national forests, by States, estimated as of December 31, 1928*

State	Beaver	Antelope	Bear		Caribou	Deer	Elk	Moose	Mountain goat	Mountain sheep
			Black or brown	Grizzly						
Alaska	3,785		[1] 6,100	[2] 2,500	20	60,350	10	550	9,500	2,000
Alabama			25			200				
Arizona	187	2,401	402	10		62,551	1,016			288
Arkansas						1,500				
California	225	772	11,200			245,400	191			675
Colorado	43,818	115	2,598	16		30,958	8,976		10	3,721
Florida			25			650				
Idaho	16,004	2,430	5,396	127		60,824	8,431	598	2,934	1,508
Michigan	6		50			175				
Minnesota	6,020		1,455		3	8,500		2,276		
Montana	18,150	520	5,713	490		50,220	11,639	1,257	4,082	2,212
Nebraska	2					50				
New Hampshire	4		800			3,200				
New Mexico	1,402	1,042	909	16		48,610	227			175
Nevada	326	220				6,125				180
North Carolina			100			4,403	43			
Oklahoma		11	5			300	350			
Oregon	5,192	75	6,992	1		76,370	6,685	9		45
Pennsylvania	50		200			1,350	15			
South Dakota	1,449	396				4,339	1,106			
Tennessee			16			118				
Utah	4,123		449	6		40,574	2,831			190
Virginia			500			58	75			
Washington	8,800		7,470	100		28,363	9,019		2,772	10
West Virginia			200			30				
Wyoming	8,084	512	1,626	181		12,785	27,604	2,281		2,820
Total	117,627	8,494	52,231	3,447	23	748,003	78,218	6,971	19,298	13,824

[1] Black bear only.

[2] Includes Alaska brown bear.

The national forests contain over 100 State game refuges and 16 Federal refuges, covering all told more than 20,000,000 acres. Elsewhere the forests are open to the taking of game and fish, within the limitations prescribed by the general game laws of each State.

Forest officers cooperate extensively with the State authorities in game-law enforcement. In 1928, 276 cases were referred to State officers for prosecution, with 190 convictions. Forest officers themselves prosecuted 181 cases, resulting in 88 convictions. They also issued 5,584 game licenses and examined 31,144 licenses.

While the State laws govern the taking of game and fish on the forests, the wild life is one of the forest resources administered for the use and enjoyment of the public. Federal ownership and administration of the land aims at obtaining the greatest possible beneficial use of all resources, and this gives game administration a definite place in administrative planning and activities.

As was stated in last year's report, the major problems of national-forest game administration concern (1) methods of increasing the supply of game where it has become depleted, (2) reliable estimates of the amount of game on each forest, (3) reliable estimates of the game-carrying capacity of each forest, and (4) methods of holding the number of game animals in balance with carrying capacities.

Planting game animals on areas where valuable species have been exterminated is one of the ways of increasing the game population. An example is the placing last year on the Medicine Bow National Forest, in Colorado, and on the Wichita National Forest, in Oklahoma, of a few mountain sheep obtained by donation from the Dominion Government of Canada. Several lambs have already been born, and the prospects seem good for the establishment of these plants.

Where forests are overstocked with game, breeding stock can be spared for use on other forests or for plants on lands outside the forests. Many requests for deer to restock areas in the eastern section of the United States are received. At present the supply of deer available for this purpose on the eastern forests is very limited, and attempts to use western deer for this purpose have not been very successful.

Plans are being developed, however, on the Pisgah Forest, in North Carolina, for trapping animals on the Federal game refuge there, which is becoming overstocked, for planting elsewhere. Requests for buffalo are also frequently received. A limited number of these animals can be furnished from the Wichita Forest in Oklahoma, but the principal source of supply is the National Bison Range in Montana, administered by the Bureau of Biological Survey.

Exact information regarding the number of game animals in a given territory is essential for good game management, particularly when the game uses the same range as domestic livestock. Without such knowledge, if the ranges are overgrazed, reductions can not be satisfactorily apportioned. It is equally important to have reliable means of determining the carrying capacity for game animals of each range unit. Regulation necessitates knowing both the number of animals on the area and the number for which feed is available. Careful studies of the feed habits of game and more satisfactory ways of taking a game census are required. Studies dealing with the vital statistics of game and their proper management are likewise necessary if use of the game resources is to be wisely correlated with other phases of forest conservation.

On several forests in New Mexico, Arizona, and California and in some places in the East deer have increased to the point of overpopulation. The acute situation that has resulted on the Kaibab Forest, in northern Arizona, has been repeatedly set forth in reports of previous years. Pronounced overstocking is now in evidence also on portions of the Gila Forest, in New Mexico, and the Coronado Forest, in Arizona. This necessitates knowledge both of the extent to which the herds should be reduced and of the best means of getting rid of the surplus. Relations with the State and local authorities are involved, and the problems presented can be met most successfully through cordial cooperation and careful joint planning. Steps have recently been taken to secure full cooperation between State game departments, the Bureau of Biological Survey, and the Forest Service.

On the Grand Canyon Game Preserve, in Arizona, supervised hunting is being used to bring the deer herd down to the carrying capacity of the range. Definite hunting areas have been established and the number of deer to be removed has been determined. Hunters are required to stay at fixed camps supervised by a deputy game warden. The number and sex of animals allowed each hunter is specified. Adequate guide service is provided, and a close check is kept upon all animals removed and upon the distribution of hunters. Under this plan in the last three years more than 2,000 hunters have taken about 2,000 deer.

On the Teton National Forest, in western Wyoming, certain range reserved but not at present fully utilized for winter elk range has been applied for by sheepmen. Urgent representations have been made both for and against the change. The question raised by the application makes necessary a careful determination of the needs of domestic livestock in the region, the needs of game animals and of recreationists, and the requirements of other related uses. These needs must then be given priorities according to their relative public importance. In solving this problem, as in many others, an essential starting point is full recognition of the practical and scientific sides of game-resource administration, as well as of the need for protection.

WATER POWER

On June 30, 1929, 259 water-power permits or easements issued by the Department of Agriculture were outstanding. This is 13 less than a year earlier. The decrease is due to abandonment of proposed power projects or of existing power structures, and to relinquishment of permits or easements in order to get rights under the provisions of the Federal water power act. Of the outstanding 259 permits or easements, 175 require the payment of an annual rental; the rest are free. For 59 rental permits for power projects the estimated average output at minimum discharge is 516,286 horsepower, and for the 62 free permits for power projects 26,089 horsepower. The permits or easements involving transmission lines only included 116 rental permits, with a transmission length of 923.46 miles within the forest boundaries. Twenty-two transmission permits without rental charge cover a length of 155.40 miles within the forest boundaries.

At the close of the fiscal year the Forest Service, at the request of the Federal Power Commission, was supervising operations of 295 permittees or

licensees, an increase of 38 cases during the year. The commission requested the Forest Service to make field investigations and reports in 61 cases of application for permit or license. The Forest Service reported on 63 cases and also made several valuations and appraisals. Of the 100 projects for which application was received by the Federal Power Commission during the year, 55 involved the use of national-forest land. The district foresters issued 14 permits for projects of 40 horsepower or less and for periods not exceeding 10 years.

An expedition known as the Alaskan Aerial Survey Detachment, representing cooperation between the Navy, the Department of the Interior, and the Department of Agriculture, is now engaged in completing the aerial survey of southeastern Alaska, partially made in 1926. The purpose of this survey is to obtain material for the compilation of maps of areas whose topography is so rugged as to make mapping by regular ground methods very difficult. The benefits derived from the 1926 work have been very great, and already this season a hitherto unknown power site of more than 20,000 horsepower has been discovered in the Tongass National Forest. The potential value of this one discovery more than offsets the entire cost of the survey.

Because of a decision by the Attorney General that this department is without authority to transfer water-power permits, present procedure requires that when the rights to or interests in structures on land under a power permit from the Department of Agriculture are sold or transferred by the permittee or by operation of law, the successor in interest must apply to the Federal Power Commission for a permit under the provisions of the Federal water power act. During the year several applications for transfers involving change in ownership as well as a change in name were made to the Forest Service. Upon being informed that this department could not make the transfers, the permittees or the successors in interest questioned the Attorney General's ruling on several grounds. As large amounts of money are involved in these cases and as other similar cases will arise, it was decided to request the Attorney General to review his earlier decision. The results of this review are expected soon.

ROADS

Tables 20 to 24 show the appropriations, expenditures, balances, and progress made in connection with forest roads. Both expenditures and accomplishments were decidedly greater than in the preceding year, when the Bureau of the Budget limited the total expenditure to $7,500,000. The work is now governed by what amounts to a mandatory law that the money available for obligation shall be promptly obligated and that the work shall be pushed to the extent that the authorizations and appropriations thereunder make possible. As a result the difference between the total authorizations to obligate and the total appropriations under them is less than at any time since the passage of the Federal highway act. From present indications, the difference for the forest road development fund will practically disappear during the next year. The same is true of the forest-highway fund to the extent that is possible with work handled under contracts normally running into two fiscal years.

TABLE 20.—*Classification of mileage in forest road and trail systems and expenditures required to complete system to satisfactory standard*

Class	Total	Satisfactory standard	Unsatisfactory standard	Non-existing	Expenditures required to complete
	Miles	*Miles*	*Miles*	*Miles*	*Dollars*
Forest highways	15,332	6,003	8,142	1,187	152,648,007
Forest development roads	45,799	19,279	11,634	14,886	56,394,626
Trails	131,087	90,383	10,291	30,413	5,286,020
Total					214,328,653

TABLE 21.—*Construction, improvement and maintenance of roads and trails from forest road appropriations and other Federal and cooperative funds by States, June 30, 1929*

State	Fiscal year 1929				Total to June 30, 1929		Expenditure to June 30, 1929		
	Constructed		Maintained		Constructed				
	Roads	Trails	Roads	Trails	Roads	Trails	Federal funds	Cooperative funds	Total funds
	Miles	*Miles*	*Miles*	*Miles*	*Miles*	*Miles*	*Dollars*	*Dollars*	*Dollars*
Alabama	76.5		111.5		102.5		87,939.39	2,275.00	90,214.39
Alaska	20.4	29.7	200.6	103.0	217.8	356.5	4,192,718.13	319,803.74	4,512,521.87
Arizona	358.7	81.0	1,085.0	897.5	1,341.4	1,583.0	4,808,477.08	860,561.64	5,669,038.72
Arkansas	31.2	20.0	208.0	167.0	410.4	518.9	936,049.55	26,247.73	962,297.28
California	487.1	482.9	3,487.9	6,495.7	2,030.2	3,099.6	12,095,574.29	4,425,782.54	16,521,356.83
Colorado	108.6	247.7	700.6	8,071.3	1,272.8	4,352.3	5,949,104.73	864,932.23	6,814,036.96
Florida	81.0		62.9		210.9		338,728.33	136,411.18	475,139.56
Georgia	6.5	11.5	62.1	182.2	54.6	1°0.6	379,690.58	38,337.99	418,028.57
Idaho	110.3	1,732.5	1,805.7	11,151.3	1,886.6	10,580.4	12,122,527.65	1,594,898.62	13,717,426.27
Illinois							414.33		414.33
Kansas					3.4		2,111.51		2,111.51
Kentucky							808.72		808.72
Maine			5.3	40.8	5.3	40.8	37,602.87		37,602.87
Maryland							70.05		70.05
Michigan			280.0		31.2		71,438.61	393.45	71,832.06
Minnesota	22.1	27.1	112.2	329.6	352.6	139.1	689,044.75	250,408.12	939,452.87
Montana	52.7	1,613.0	1,195.0	8,584.0	940.4	5,416.3	7,367,611.68	612,084.59	7,979,696.27
Nebraska	.6		22.6		46.9		74,300.76	990.80	75,291.56
Nevada	1.9	53.5	217.7	382.8	429.5	831.0	1,232,859.94	147,881.06	1,380,741.00
New Hampshire	2.0	61.5	39.0	377.0	42.6	438.0	268,508.16	18,474.83	286,982.99
New Jersey							217.71		217.71
New Mexico	122.5	86.0	644.3	1,469.5	777.9	1,444.3	3,632,751.68	308,453.93	3,941,205.61
New York							81.32		81.32
North Carolina	20.0	1.0	180.2	596.2	196.5	604.5	636,543.44	60,612.35	697,155.79
North Dakota					1.0		57.75		57.75
Oklahoma			34.1		24.7	16.5	50,977.74	12,362.16	63,339.90
Oregon	324.6	1,418.1	4,229.8	8,699.6	2,798.6	6,110.8	11,299,205.67	5,649,226.71	16,948,432.38
Pennsylvania	1.3		69.0		47.0		74,072.89	1,155.00	75,227.89
Porto Rico				36.0	4.6	36.3	17,239.41	550.00	17,789.41
South Carolina		14.2	16.9	4.0	16.3	18.2	97,354.53	15,659.81	113,014.34
South Dakota	11.4		151.8	14.8	279.6	61.7	718,977.48	199,121.37	918,098.85
Tennessee	4.0	19.0	57.7	514.1	93.1	476.6	346,360.06	134,002.88	480,362.94
Utah	36.2	151.8	625.2	1,228.8	1,026.4	3,304.5	3,086,924.06	763,880.77	3,850,804.83
Virginia	7.0	2.0	148.4	529.5	110.4	729.6	490,516.02	37,581.21	528,097.23
Washington	81.5	1,304.4	1,043.8	7,516.3	951.6	4,459.9	7,262,423.06	1,541,403.84	8,803,826.90
West Virginia	9.5	60.7	87.8	241.7	59.0	325.7	156,366.28	5,299.98	161,666.26
Wyoming	35.1	35.5	536.7	4,641.9	964.7	2,040.0	3,867,968.53	376,252.06	4,244,220.59
Total	2,012.7	7,453.1	17,421.8	62,274.6	16,730.5	47,175.1	82,393,618.79	18,405,045.59	100,798,664.38

TABLE 22.—*Distribution among the States of the apportionments for the fiscal year 1930*

State	10 per cent fund	Forest highway fund	Forest road development fund	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*
Alabama	75.57	3,465.00	11,727.00	15,267.57
Alaska	8,251.56	460,509.00	18,783.00	487,543.56
Arizona	37,059.42	282,288.00	148,487.00	467,834.42
Arkansas	7,563.35	41,917.00	69,471.00	118,951.35
California	142,645.49	677,175.00	481,881.00	1,301,701.49
Colorado	49,886.12	328,044.00	151,776.00	529,706.12
Florida	3,155.90	11,436.00	16,209.00	30,800.90
Georgia	1,340.55	7,605.00	23,574.00	32,519.55
Idaho	62,771.25	491,648.00	623,205.00	1,177,624.25
Illinois		391.00		391.00
Maine	566.44	1,365.00	2,399.00	4,330.44
Michigan	674.15	3,581.00	1,331.00	5,586.15
Minnesota	2,850.03	29,268.00	20,751.00	52,869.03
Montana	26,387.56	397,999.00	253,177.00	677,563.56
Nebraska	958.48	4,659.00	1,013.00	6,630.48

TABLE 22.—*Distribution among the States of the apportionments for the fiscal year 1930*—Continued

State	10 per cent fund	Forest highway fund	Forest road development fund	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*
Nevada	9,252.31	94,463.00	14,807.00	118,522.31
New Hampshire	7,812.84	21,399.00	10,504.00	39,715.84
New Mexico	13,950.75	202,401.00	104,522.00	320,873.75
North Carolina	3,061.92	12,782.00	30,332.00	46,175.92
Oklahoma	456.89	1,982.00	223.00	2,661.89
Oregon	106,007.34	632,638.00	477,603.00	1,216,248.34
Pennsylvania	404.89	7,403.00	17,346,00	25,153.89
Porto Rico	24.99	533.00	135.00	692.99
South Carolina	506.75	1,474.00	4,605.00	6,585.75
South Dakota	17,195.31	39,481.00	14,219.00	70,895.31
Tennessee	1,192.31	11,853.00	34,653.00	47,698.31
Utah	20,514.82	166,445.00	60,664.00	247,623.82
Virginia	3,695.31	14,997.00	38,377.00	57,069.31
Washington	67,111.71	332,614.00	256,187.00	655,912.71
West Virginia	698.12	6,673.00	25,074.00	32,445.12
Wyoming	29,783.76	211,512.00	86,965.00	328,260.76
Total	625,855.89	4,500,000.00	3,000,000.00	8,125,855.89

TABLE 23.—*Distribution among the States of the total apportionments including the fiscal year 1930*

State	10 per cent fund	Section 8 fund	Federal forest road construction fund	Forest highway fund	Forest road development fund	Total
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Alabama	808.01	15,456.04	1,922.31	27,811.00	55,935.00	101,932.36
Alaska	150,404.03	470,080.01	193,549.95	4,029,825.00	199,519.00	5,043,377.99
Arizona	569,356.48	679,628.89	501,984.55	2,436,536.00	1,198,157.00	5,385,662.92
Arkansas	99,327.11	174,939.40	128,773.38	303,547.00	408,218.00	1,114,804.89
California	1,354,080.86	1,462,824.02	1,206,815.23	5,921,874.00	3,563,348.00	13,508,942.11
Colorado	642,823.07	759,622.61	777,307.26	2,909,809.00	1,446,028.00	6,535,589.94
Florida	33,893.23	119,528.14	21,534.94	99,297.00	121,011.00	395,264.31
Georgia	9,747.41	52,325.41	134,387.16	71,733.00	142,436.00	410,628.98
Idaho	845,221.45	1,197,509.73	1,367,402.82	4,418,880.00	5,428,515.00	13,257,529.00
Illinois				1,556.00	396.00	1,952.00
Kansas	1,867.27					1,867.27
Kentucky	722.72				86.00	808.72
Maine	2,769.53	32.41	3,738.77	11,232.00	21,884.00	39,656.71
Maryland	70.05					70.05
Michigan	2,690.73	115.63	3,000.00	21,457.00	57,118.00	84,381.36
Minnesota	34,362.65	8,215.41	108,352.03	254,853.00	326,118.00	731,901.09
Montana	540,998.07	755,919.22	731,497.39	3,518,250.00	2,800,271.00	8,346,935.68
Nebraska	17,613.92	18.98		42,801.00	27,851.00	88,284.90
Nevada	157,380.07	194,918.55	82,265.33	838,928.00	117,885.00	1,391,376.95
New Hampshire	36,179.29	341.66	10,941.30	148,061.00	125,176.00	320,699.25
New Jersey	118.99				83.00	201.99
New Mexico	325,158.90	430,170.33	509,215.36	1,833,496.00	959,322.00	4,057,362.59
New York	4.00				20.00	24.00
North Carolina	31,784.15	84,801.99	176,890.28	115,306.00	255,166.00	663,948.42
North Dakota	45.75	7.00				52.75
Oklahoma	8,972.44	65.49	2,775.17	20,350.00	22,520.00	54,683.10
Oregon	909,295.89	1,430,677.15	1,077,552.29	5,061,631.00	4,042,461.00	12,521,617.33
Pennsylvania	1,871.83	24.04	21.42	30,012.00	69,787.00	101,716.29
Porto Rico	28.69	7.00	3,343.09	5,410.00	11,948.00	20,736.78
South Carolina	2,230.38	402.10	48,028.61	12,229.00	43,742.00	106,632.09
South Dakota	153,690.86	83,674.78	79,341.53	317,275.00	185,236.00	819,218.17
Tennessee	17,177.24	103,433.37	28,092.79	90,151.00	175,282.00	414,136.40
Utah	361,049.98	445,632.53	464,562.35	1,495,147.00	571,421.00	3,337,812.86
Virginia	38,816.31	58,390.16	71,902.26	126,964.00	245,342.00	541,414.73
Washington	547,860.46	939,348.21	712,201.40	2,872,412.00	2,810,816.00	7,882,638.07
West Virginia	4,802.58	12,830.41	5,049.24	40,811.00	126,515.00	190,008.23
Wyoming	379,786.69	471,800.49	547,551.79	1,922,356.00	940,387.00	4,261,881.97
Undistributed		47,258.84				47,258.84
Total	7,283,011.09	10,000,000.00	9,000,000.00	39,000,000.00	26,500,000.00	91,783,011.09

TABLE 24.—*Condition of forest road funds on June 30, 1929*

Fund	Appropriations	Expenditures	Unexpended balance
	Dollars	*Dollars*	*Dollars*
10 per cent	6,656,998.28	6,293,113.29	363,884.99
Section 8	10,000,000.00	9,865,984.86	134,015.14
Federal forest road construction	9,000,000.00	9,000,000.00	
Forest highway	34,500,000.00	32,453,559.15	2,046,440.85
Forest road development	23,500,000.00	23,040,810.49	459,189.51
Total	83,656,998.28	80,653,467.79	3,003,530.49

The determination of a standard series of road signs has been pushed. Some changes and additions will be advisable as a result of further experience and as increased needs develop. The Forest Service standards are applicable to the forest roads on the forest-development system and on the county and community system. These standards are consistent with and modeled on the standards which have been adopted for the United States highways, and which the States are expected to approve for the State highways.

The service requirements on the forest-development roads that the Forest Service is constructing are small in nearly every case, so that a low-standard road adequately meets the needs. In matters of width, gradient, and alignment there are marked differences from the forest highways, constructed under the supervision of the Bureau of Public Roads. Equipment and construction methods required for the high-standard roads do not meet the needs for the low standard. During the past two years improvements in equipment and the use of equipment manufactured primarily for other purposes have made possible decided changes in the construction methods, and lowered costs. The new equipment does not yet exactly meet our needs, but improvements and redesign by the manufacturers are expected. The advantages and disadvantages of various types of equipment and methods were thoroughly demonstrated at a field meeting on the Santa Barbara Forest in April.

One of the most interesting developments has been the construction of motor ways in certain regions heavily covered with brush, of which mention was made earlier in this report. A tractor of from 60 to 75 horsepower attached to a heavy grader, and occasionally a road ripper, is the equipment used. While this method is adapted to only a small percentage of the total national-forest area it is very successful where the conditions are suitable. A satisfactory means of transportation is secured for from $100 to $300 a mile.

The objective in the forest-development work is to provide the kind of road that will render the required service at the minimum cost for construction and maintenance. Decided progress toward this objective was made during the year. Also a new method has been worked out for determining the most advantageous and economical location, mileage, and standard of roads and trails and the number and location of smoke chasers. This method is apparently both feasible and very satisfactory, but it has not yet been given a thorough demonstration through working out the complete plans for several forests. It is expected that this will be done during the coming year.

Roads required for the protection and utilization of the forests are as essential to the public as those which are sections of the Federal-aid and the State and county road systems. It is very important that the construction of these forest-development roads be advanced as rapidly as possible, and in balance with the forest highways, so that the proposed development system will be completed along with the forest-highway system.

MAPS AND SURVEYS

During the year the Forest Service published for its administrative use 26 national-forest maps on the scale of one-fourth inch to the mile, 13 maps on the scale of one-half inch to the mile, and 2 maps on the scale of 1 inch to the mile. Six presidential-proclamation diagrams were issued in cooperation with the Department of State.

A triangulation net of third-order accuracy was extended over a portion

of the Datil National Forest, in New Mexico. This net gave sufficient control points from which to initiate grazing and timber-survey projects. Two topographic surveys on a field scale of 2 inches to the mile were made on the Klamath and Shasta National Forests. Two drainage surveys were made on the Nezperce National Forest, in Idaho, and the Wyoming National Forest, in Wyoming. Numerous smaller timber, grazing, and land-exchange areas were also topographically surveyed.

The aerial survey work on the Nezperce National Forest, which had to be abandoned in the fiscal year 1928, was resumed. Approximately 170 square miles of the northern part of the forest was photographed vertically. A mosaic map embracing 22 square miles of this area was made on a scale of 6 inches to the mile.

In connection with the acquisition of lands in the East, 817 miles of boundary lines were surveyed at a cost of about $55 per linear mile.

The drafting organization compiled, revised, or traced 24 base maps of national forests. Nine atlas pages showing culture, drainage, and contours were prepared for western forests, while 72 atlas pages were drafted for the eastern forests. One thousand three hundred and sixty type maps and atlas pages were colored. One hundred and fifty graphs showing research data were compiled, besides numerous posters, range maps, status and ownership maps, organization charts, and naval-stores graphs.

Work in connection with the Mississippi flood-control reports was continued, and maps of a far more detailed character than those of the preceding year were prepared. The 6 major basins of the previous study were expanded into 80 or more subbasins, necessitating further research and a far more definite treatment. Twenty-two separate maps and graphs were made for this project. A special report on forest conservation required 32 separate maps and graphs, of which 12 were drafted on a large scale for exhibit purposes.

The photographic laboratory made over 3,700 lantern slides and approximately 97,000 square feet of blue prints, Van Dyke, photostat, and solar bromide prints, besides mounting over 40,000 square feet of maps on cloth. Over 3,900 square feet of wet plates were sensitized and exposed. In addition 69,000 photographic prints were made, of which 760 were mounted. Over 5,000 rolls of films were developed, and about 3,800 square feet of photoview enlargements were made.

The General Land Office is able to handle all administrative needs for township surveys and resurveys. During the year 55 township surveys were initiated, and 101 were completed.

The Geological Survey surveyed approximately 3,400 square miles of national-forest land. This is less than 2 per cent of the total unmapped area.

RESEARCH

As the research activities of the Forest Service progress it becomes increasingly evident that to work out successfully the great forest problems of the country all the forms of research that are now being brought to bear on the problem need to be utilized on a larger scale and organized in a correlated, carefully directed, planwise attack. The problem is exceedingly complex. It calls for full knowledge of the location, quantity, and quality of our present forest supplies; of the methods of forest management necessary to grow forest supplies of different kinds under the most diverse conditions in widely separated regions; of the costs of growing timber; of the character of our present requirements for forest products, and their regional location; of the character and extent of such needs for the future; of the structure, composition, and properties of wood and the best methods of utilizing it industrially; and of almost innumerable kindred matters that in one way or another will have a part in determining the future of our forests.

Under the provisions of the McSweeney-McNary Act, a start is being made in such an expanded and correlated attack. As it takes shape it is becoming clear that in very large degree our research problems lend themselves to regional analysis.

When the first regional forest experiment stations were established, in 1921, the studies carried on dealt mainly with timber growing and forest-fire protection. It now appears that some of the forest investigations dealing with forest economics, range management, and forest products can be best handled under the same regional organization. There are, however, certain classes of problems dealing with the utilization of forest products which are nation-wide in scope and which require the facilities of a thoroughly equipped laboratory for their solution. Such problems can be

best handled by centralizing their study, as is being done at the Forest Products Laboratory, at Madison, Wis. As the investigative program develops, however, it is becoming evident with regard to an increasing proportion of the forest-research projects that they require to be handled jointly by the regional experiment stations and the Forest Products Laboratory, working in the closest cooperation.

To obtain the advantages of regional unification of research activities in silviculture and in forest products the separate office of forest products previously maintained under the district forester at San Francisco was last year made a part of the California Forest Experiment Station. The principle is being further expanded to include at this station and at the Great Basin, Lake States, and Southern Forest Experiment Stations research in erosion control, for which the 1930 agricultural appropriation act made special provision. The southern station is also making plans for a regional study of the financial aspects of forestry. The forest survey authorized by the McSweeney-McNary Act is being inaugurated regionally by the Pacific Northwest Forest Experiment Station. Closer cooperation between the Forest Products Laboratory and the various regional experiment stations is being brought about by the appointment of joint committees and by the detail of men from the regional stations to the laboratory when problems making this course advantageous are under investigation.

Thus research will go forward at the regional forest experiment stations not only in silviculture but also in forest economics, range management, and to some extent in forest products. The investigations in forest products at the stations will consist very largely of regional and local field studies.

The unification of regional research also provides better means of cooperating with other bureaus of the Department of Agriculture in the various lines of their work which are closely related to forestry problems. Last year two forest pathologists under the direction of the Bureau of Plant Industry were assigned to the Southern Forest Experiment Station, in addition to the men already assigned to forest experiment stations in other regions and to the Forest Products Laboratory. This year the Bureau of Entomology has assigned a man to work with the Pacific Northwest Forest Experiment Station. Other entomologists are established at the northeastern, at the Appalachian, and at the California stations. As a result of the increase in appropriations for forest wild-life investigations, the Bureau of Biological Survey will be able during the fiscal year 1930 to place two men at forest experiment stations, one of these to be assigned to the Appalachian and one to the Lake States station.

The funds made available for research activities under various appropriation items for the fiscal year 1929 are compared with the amounts for 1928 and for 1930 in Table 25. The 1928 funds were in part provided through allotments from general appropriations for Forest Service salaries and expenses.

TABLE 25.—*Appropriations for 1929 as compared with those in 1928 and 1930*

Class of research	Appropriations for fiscal year—		
	1928, directly appropriated and allotted [1]	1929, directly appropriated [2]	1930, directly appropriated
Silvical investigations	$353,080	$377,407	$413,000
Forest products investigations	503,420	542,596	585,000
Range investigations	49,755	52,680	67,000
Forest taxation study	48,665	63,640	65,000
Forest insurance study	-------	-------	10,000
Forest survey	-------	-------	40,000
Forest economic studies	-------	-------	25,000
Erosion studies	-------	-------	30,000

[1] Includes following allotments from other appropriations: Silvical investigations, $16,080; forest products investigations, $3,420; and range investigations, $4,875.

[2] Includes Welch Act increases.

FOREST-ECONOMICS INVESTIGATIONS

In the study of forest taxation, field work was concluded in the Pacific Northwest and a large part of the data compiled. The same is true of a preliminary taxation study conducted in New Hampshire. Advance tables presenting such of the results as could be prepared soon enough were furnished the State forest and tax authorities in Oregon and New Hampshire, respectively, for the legislative sessions of those States. They proved especially timely in Oregon, where forest-tax legislation was in the process of framing and enactment. Tables dealing in detail with conditions in Grays Harbor

County, Wash., were furnished the Western Forestry and Conservation Association for use in connection with a Grays Harbor regional economic and forestry investigation. An office study of the methods by which forest lands are taxed in Europe was initiated.

The policy of making public progress reports was continued, and two were issued. One, which has been in great demand, was a digest of the State forest-tax laws in effect on January 1, 1929, together with a brief historical summary of tax legislation and a table showing the more important provisions of State forest laws.

Statistics of lumber production in 1928 were gathered in 12 Western States, in cooperation with the Bureau of the Census. The Forest Service handles about one-ninth of the schedules, but the returns include 44 per cent of the total lumber cut. In the same canvass questionnaires were obtained showing lumber distribution in 1928. This project was expanded to show, not only the quantities shipped from each State to every other State, but also the shipments to the several Canadian Provinces and to the principal countries of other continents. The Canadian Bureau of Statistics is cooperating by gathering for the first time statistics showing the distribution of shipments from the United States within the Dominion, and the source and destination of its lumber exports. It is proposed to combine these results to give a fairly comprehensive picture of the quantities and sources of lumber consumed in all parts of North America north of Mexico.

Data on stumpage and log prices, principally from 1900 to 1928, have been accumulated which lend themselves to compilation by species and regions, and upon other bases of classification. They should prove increasingly valuable in connection with forest economic studies. The figures for 1927, as for 1925 and 1926, disclose a tendency to break the long-continued upward trend of prices.

A several years' study of the economic relationship of forests to the whole economic system of a region, and of the results of the destruction of this resource, produced a publication on the economic aspects of forest destruction in northern Michigan. This is believed to be the most comprehensive and instructive study undertaken in its field. Cooperation was given to the Wisconsin Agricultural Experiment Station in a study of the use and taxation of land in Lincoln County of that State, which resulted in a publication setting forth the problem of tax delinquency, its relation to land-use problems, and constructive suggestions for meeting the northern Wisconsin situation. Through addresses and published articles contributions were made to the development of thought on the increasingly important subjects of the relation of forestry to farm relief, the relation of the forests of the Pacific Northwest to New England forestry, and problems in determining the economic feasibility of land use for forest purposes.

The extension of private forestry practice, the development of sound public and private programs of land use, and the practical application of the findings in the several fields of forest research hinge largely upon economic conditions and forces. Investigations in the field of economics, however, have lagged far behind the forestry studies in other fields. More definite recognition was given to this highly important field by the appropriation for the fiscal year 1930. The most important project inaugurated is a forest survey to secure an accurate, detailed, and comprehensive appraisal of the Nation's present and future requirements for forest products, the present and potential forest growth, the present situation as to volumes and quality of timber and as to areas and condition of forest lands, and the economic influences and relationships involved. This is essentially a land-use study, designed to lay a broad foundation of economic facts as a basis for productive forest-land use. As a first step the Forest Service, in cooperation with the Bureau of the Census and the National Lumber Manufacturers' Association, has initiated a statistical canvass of the wood requirements of the secondary wood-using industries, classified by kind of industry, State, species, and the form in which the wood is needed. This when related to the somewhat similar studies made by the Forest Service in the years 1909–1913, and to some future canvasses, will give reliable indications of trends in wood requirements. Two other important economic studies already initiated for the fiscal year 1930 are an investigation of the financial aspects of private forestry practice and a study of forest insurance. Both will supply information which should greatly stimulate the private practice of forestry and the development of wise land use in the United States.

RESEARCH IN FOREST MANAGEMENT AND PROTECTION

The need for early solution of the forest-management problems of the major timbered regions of the United States is urgent. Many timberland owners are considering the possibilities of forestry. Management of the national forests also presents many problems that demand silvical research. In particular the national forests that are being built up in the East through land purchases call for research. Most of the purchased lands have been lumbered and badly damaged by fire. They are being acquired partly to protect watersheds, partly to grow timber, partly to demonstrate methods of large-scale timber growing. They must be restored to good condition through the right silvicultural practices, so that their full potential timber-growing and protective capacity may be developed and maintained. Just as successful agriculture, successful forest culture demands the application of extensive scientific research that must be systematically built up.

To meet the need for research in each of the major forest regions of the United States a series of forest experiment stations is being developed. So far six have been established in the East and four in the West. All of the stations lack resources for covering fully their respective problems. Increased appropriations for the fiscal year 1930 provide for enlarging the work in the Lake States and for strengthening somewhat the naval-stores work in the South.

In formulating their research programs most of the forest experiment stations are aided by advisory councils, appointed by the Secretary of Agriculture, which bring forward the problems that most need investigation in each region. Councils appointed last year for the Central States and Allegheny experiment stations brought the total number to eight.

FOREST-FIRE STUDIES

A number of the forest experiment stations are conducting forest-fire research. In northern California the relation between fire and the different types of ground cover—grass, chaparral, brush, and the various timber types—was studied, and data were obtained upon the risk of fires starting, the quantity of fuel on the ground, the ease of controlling fires, and the rate at which fires spread. An analysis of the records of over 10,000 fires furnished valuable conclusions upon which to base more efficient protection, by establishing the length of the average fire season for each cover type, the preponderance of incendiarism in the chaparral and brush types, and the relative difficulty of protecting each type. On the basis of the rate of spread and the difficulty of control of fires in the different cover types the ratio between those easiest and those most difficult to protect was placed at 1 to 50. These facts afford a basis for placing fire guards, for determining the size of suppression crews, for the development of roads and trails, and for combating incendiarism. The study showed also that in the most valuable timber type, the western yellow pine, fires have covered annually more than 1 per cent of the entire area. At this rate, in 90 years, the fires will cover an area equal to that of the whole type.

Study by the Southern Forest Experiment Station of some severe fires that occurred in the spring of 1927 on certain cut-over longleaf and slash pine areas in southern Georgia, following two months of deficient precipitation, afforded data on the relative destruction under varying surface conditions and in stands of varying age. Areas which had been burned annually had no living pine reproduction upon them. Another study made upon a loblolly pine stand in Louisiana disclosed that the growth in three years after a fire that occurred in 1924 was only 72 per cent of that in the three years before the fire, or a loss of 325 board feet per acre for the three years. With the vast area of pine land in the South that is burned each year, the aggregate loss from impaired growth rate, to say nothing of the losses in the form of young growth killed and mature timber destroyed, is tremendous.

An analysis by the Lake States Forest Experiment Station of Minnesota and Michigan forest-fire statistics gave valuable information upon the seasonal occurrence, concentration, and causes of forest fires in those States, and a study of the effect of weather conditions and forest cover on fire hazard in that region was initiated.

The Northwestern Forest Experiment Station studied methods of felling snags, including the method mentioned on p. 27, in which an electric machine is used to bore holes for blasting the snags down with powder. A 110-volt dynamo set up on a truck furnished the power. With this equipment it

was found that snags could be felled cheaply and quickly, and a fairly good control of the direction of fall was obtained.

This method is applicable only in country accessible to a truck. Attention is now being given to devising a portable boring machine and a light gas-engine dynamo that can be packed into the more inaccessible mountain regions. The blasting method of snag falling has already been used with good results in fighting fire.

At the Northern Rocky Mountain Forest Experiment Station fire data were analyzed that have been collected since 1922, and conclusions were published concerning the elements of danger. Six degrees of duff inflammability have been distinguished, the effect of each of the weather elements has been determined, and the weather forecasts can now be translated into predictions of forest inflammability. As an adjunct of this work a high degree of cooperation between the Weather Bureau and the Forest Service has been effected. Through the results of the study and cooperation with the Weather Bureau the efficiency of forest-fire protection by State, Federal, and private agencies has been decidedly improved.

NAVAL STORES

The Florida branch of the Southern Forest Experiment Station continued its study of naval-stores extraction. On the experimental area at Starke tests begun in 1923 were completed and the data largely analyzed. Several new tests upon a total of 4,170 trees were started. In the height-of-streak tests quarter-inch chipping of slash pine showed for the 5-year period a 6 per cent greater yield than half inch, and a 7 per cent greater yield than ¾-inch chipping. The gain came entirely during the last two years. In longleaf pine, where openness of the stand created conflicting conditions, half-inch chipping gave the highest yield, and quarter inch the lowest. Narrow chipping always results in a face that can be worked from two to five years longer than is the case with wide chipping. Depth-of-chipping tests upon both slash and longleaf pines gave the best results with a half-inch depth, although for the first two or three years deep chipping produced heavier yields. The shallower chipping is superior mainly because it permits a more healthy condition of the trees. Width-of-face tests have been carried on for three years, and indicate increased gum yields with increases in the width of faces, but not in the same ratio.

SOIL EROSION

There is a growing interest in soil conservation. In many parts of the United States serious losses of soil fertility have occurred, a great area of valuable farm land has been ruined, and streams and reservoirs have been silted up. Much of the tremendous burden of silt carried by the Mississippi River comes from forest lands or lands which should never have been placed under the plow. Congress has this year given money for a study of erosion and part of it will be used by the Forest Service to study methods of erosion control in the loess-soil region along the lower Mississippi, where the damage has been particularly heavy, and in California, where erosion from burned chaparral and forest areas has caused the loss of many farms, has silted reservoirs, and has destroyed much other property. The purpose of the studies will be to determine the part that forests play in the control of erosion under the local conditions

Data upon flood conditions in the Mississippi River basin collected by the four eastern forest experiment stations led to the conclusion that the present forests of the Mississippi watershed retain water to an amount equivalent to a reduction of more than 1 foot in the flood crest, and that by proper protection, care, and management the amount might be raised to more than 4½ feet.

Recent and as yet uncompleted investigations by the California Forest Experiment Station indicate that the surface run-off from forest soils from which the litter has been removed is from 10 to 30 times greater than from soils with a complete and undisturbed mantle of forest litter. The reason for this is simple—that when muddy water percolates into the ground the fine material carried in suspension is deposited close to the surface, where the particles clog up the pores in the soil. Thus the ground is made impervious. A forest cover breaks the force of the rain and keeps the water clear, while any pore-clogging material that may be picked up is strained out by the surface litter, so that when the water reaches the soil it is absorbed easily and rapidly. The California studies show that in comparison with the function performed by the forest litter

in maintaining the percolation capacity of the soil, its spongelike function as an absorbent of water, commonly regarded as one of its major protective functions, is insignificant.

In a laboratory experiment, after clear water had been run for 10 days through four tubes of soil, muddy water was substituted in two of them. In four hours their discharge dropped from 1,000 cubic centimeters an hour to 500, and after 10 days was down to 90 cubic centimeters. Meanwhile the discharge from the other two tubes, that were receiving clear water, remained constant. Muddy water was then turned into them also, with practically the same result that the first two tubes had given. It has been known in southern California for many years that muddy water may not be spread upon the gravelly débris at the mouths of the canyons if the water is to be stored in the underground artesian basin. Where muddy water has been so distributed the interstices in the surface gravel beds are effectively sealed and the result is as though the gravel were covered with an impervious coating.

This sealing effect of muddy water on bare soils accounts in large measure for the great differences that exist between run-off from a forested area and from a barren or denuded one. From the latter the discharge, with even a moderate rainfall, is likely to take the form of a flash flood; on the former most of the water is normally absorbed into the lower soil levels. The difference in erosive effect is of course enormous.

In the central-hardwood territory, extending from Ohio to Iowa and south to and including Tennessee, served by the Central States Forest Experiment Station, clearing of the land for agriculture has been carried beyond the point justified by the topography and the demand for farm products. Many thousands of acres of improved farm land in the hilly portions have already been abandoned, and many more probably will be in the near future. The remaining forest areas have been greatly damaged by fire, cutting, and grazing. The first meeting of the experiment station's research council indicated that the loss of valuable soil throughout the region as the result of widespread erosion demanded immediate steps for control. The station has therefore undertaken an examination of the eroded areas as the initial step in a plan for reforestation.

TIMBER-GROWING STUDIES

The Northeastern Forest Experiment Station is studying the silvicultural practices necessary to assure prompt and full restocking of pulpwood species upon spruce sites. Conditions have been found generally to be favorable for the continuous production of pulpwood crops. The study indicates that for the successful regeneration of spruce lands, nearly total dependence must be placed upon advanced growth. Spruce reproduction is normally abundant. The present practice of clear cutting the spruce from areas of mixed spruce and hardwoods results in a preponderance of hardwoods. Investigations upon areas recently logged that have a residue of large worthless hardwoods indicate that girdling of these trees to release the spruce, followed by weeding to remove the younger hardwood trees that have sprung up, will prove profitable.

The need for silvicultural research relating to the bottom-land hardwoods of the lower Mississippi Valley was brought out forcibly by a survey made last year through cooperation with the State forester of Louisiana, which disclosed that the hardwood forest lands of that region are in a far more serious condition that had been recognized. Instead of a large reservoir of old-growth timber, comparatively little of the old timber is left. Estimates indicate that relatively few lumber plants have sufficient timber to continue cutting more than 5 or 10 years. Some of the operators are asking for information as to the silvicultural measures that would put these hardwood lands in the best shape for regrowth, and as to the growth rate that could be looked for.

The existence of many plantations established during the past century in the central hardwoods region, particularly in the Prairie States where the original timber stands were scant, led to a study to determine the success or failure of different species and the yields which are being obtained. This project is now in its second year. The effects of grazing both upon the naturally forested areas and upon plantations will also be studied.

In the northern Rocky Mountain region many private owners have long wished to know the yields that might be expected at various rotations, in order to decide whether private forestry would prove advisable. The Northern Rocky Mountain Forest Ex-

periment Station has now determined that if western white pine land is well stocked with trees as the result of good seeding and fire protection, yields of from 30,000 to 40,000 board feet per acre can be obtained in 100 years on the fair sites, and from 50,000 to 80,000 at the same age on the best sites. The growth rates indicated in these fully stocked stands are sufficiently great to indicate strongly that private forestry will pay in this region.

FOREST PRODUCTS INVESTIGATIONS

The principal aim of forest-products research is to make forests and forest land of greater service. Forests serve human needs along varied lines, but in large degree their perpetuation depends upon the extent to which trees can be converted into useful commodities and the use of land to grow trees can be made profitable.

Better utilization means an enlargement of the merchantable yields per acre per year. It means not only the marketing of material now wasted in lumbering but also the marketing of species hitherto considered inferior or worthless. It involves the discovery and development of new uses for wood and wood products in the greatest possible variety. To find an effective and sufficient outlet, through industrial requirements, for what our vast forest-land area can be made to grow is just as important to our national economy as it is that industrial requirements be adequately met. The correlation of public requirements for forest material with the capacity of available forest lands to produce such material involves a twofold adjustment—of demand to supply, and of supply to demand. To promote this adjustment is the objective of the varied research projects described in the next few pages.

STRUCTURES, COMPOSITION, AND PROPERTIES OF THE MATERIAL

Wood is both a highly complex and a widely variable material. Cellulose, lignin, pentosans, and extractives are combined in variable quantities and arranged in a complicated and variable microscopic structure. The composition and the structure vary not only between different species but also within a species and within a single tree. The final composition and structure give wood all its many but varying valuable properties.

Factors of environment such as spacing, soil, and light cause many of the variations. These environmental factors are to a considerable extent subject to control. The work of the Forest Products Laboratory is becoming increasingly interrelated with that of the forest experiment stations in determining the effect of environmental growth conditions on certain qualities and properties. During the year the previous conclusions in regard to the effect of spacing on the density and strength of hardwoods were confirmed by a study of Appalachian hickory. Where the rate of growth was maintained by proper spacing of the trees the hickory wood from this section equaled the preferred hickory from farther south. Investigations were started on the effect of growth conditions on the pulping qualities of southern pines, and on the density and strength of second-growth loblolly pine in Virginia. It is planned to extend this type of work to include the intermediate factors of structure and composition.

In the field of structure the previous discovery of an outer layer of the cell wall composed of fibrils running at approximately right angles to the cell axis was extended by the examination of a large number of species, in all of which this type of cell structure was found. A smaller structural unit of which the fibrils are built up was also discovered, and named from its shape the "fusiform body." It was found that the ease of separating the fibrils in wood-pulp fibers gives a direct index of the character of the chemical and mechanical treatment used in pulping. This is expected to lead to a new technic for judging the quality of pulps and for controlling pulping processes. A technic was also developed for measuring the spiral angle of the fibrils of the inside layers, which preliminary measurements have shown to be related to the amount of longitudinal shrinkage.

Crude cellulose, which is the main constituent of wood, is different from the pure cellulose of cotton, and is of particularly complex chemical composition. Most of the cellulose research at the laboratory has been devoted to the hemicellulose (or cellulose impurities) that in wood are closely combined with the pure cellulose. The hemicelluloses, the main source of the sugars obtained from wood by hydrolysis, must be largely removed from wood cellulose before it is suitable for

use in the manufacture of such material as rayon. In cooperation with a committee of the cellulose division of the American Chemical Society a standard method was developed and recommended for the determination of alpha cellulose (the pure cellulose). It was also found that as good paper can be made from the crude wood cellulose as is made from commercial pulps, which are more nearly pure cellulose. This means that if pulping processes can be developed to retain the entire crude cellulose, pulp yields can be greatly increased without impairment of the properties of the final paper.

In the field of extractives two species have been studied extensively. In redwood the substance responsible for the red color was isolated and found to resemble the natural dyes brasilin and haematoxylin. It was also found that in drying redwood the extractives move toward the outside of the board and deposit just under the surface. Their effect on the strength properties of redwood, previously suspected, was confirmed. In western red cedar a complex organic acid was isolated that is thought to be responsible for the occasional corrosive action of the wood on metal. The study of extractives bears directly on the practical utility of wood.

Further progress was made in finding out how to improve the production of turpentine and rosin, particularly from the second-growth longleaf and slash pines of the South. Field demonstrations and other educational work were conducted to introduce the improved methods, which produced an increase of over 50 per cent in the average of recent yields in Florida. A study to determine the characteristics of high-yielding trees demonstrated that externally promising trees may produce so little oleoresin as to become a severe drain upon the returns from associated profitable trees. As in the rubber industry, the ability to select high yielders will be of primary importance. The whole field of naval-stores research has a vital relationship to southern forestry.

Every wood has 30 or more properties relating directly to the requirements of use, such as bending and compressive strength, hardness, toughness, resistance to splitting, a certain degree of resistance to decay and staining, nail-holding power, and heat-insulating capacity—all varying widely even in the wood from one tree. How to segregate the material to insure uniformity and better values, and how to modify the properties by methods of treatment, are matters requiring a basic knowledge of the properties themselves and of their variability. Much of the laboratory work is in this field. During the year a publication based upon half a million tests was completed, which presents the main mechanical properties of 164 species in form and language adapted for the practical use of wood users, distributors, and producers. Coincidentally studies were continued to determine more exactly the magnitude and causes of variability of properties. The results with redwood established, among other things, a definite distinction between the properties of virgin and of second-growth material. Since for all species increasingly second growth must be the source of supply, its properties should be comprehensively studied.

A publication was completed on the nail-holding properties of various species, and studies were continued of the relative holding power of wood of different kinds, at different stages of dryness, and with nails of different sizes and designs.

A scientific study of the torsional or twisting strength of wood members used in aircraft parts was completed in cooperation with the Navy Department. Owing to the impossibility of calculating the torsional moment of many of the sections tested, a new method was devised which resulted in a body of torsional-moment data never before obtained, applicable to members made not only of wood but of any other material.

A manuscript prepared for publication on the properties and uses of western hemlock is intended as the first of a series to bring little-used species of wood into better standing through proper correlation of their properties with use requirements.

HARVESTING THE MATERIAL

Most lumbering operations are carried on without the operator knowing definitely the qualities and sizes of logs that yield a profit. To know with any certainty where to draw the line requires dependable data on logging costs and mill returns. Studies to obtain these data are being actively prosecuted in cooperation with representative groups of timberland owners and operators. Work on typical operations in the Lake States hardwoods and the Arkansas shortleaf-pine region

has been concluded, and the results have influenced the plans of both large and small timberland owners toward sustained-yield operations. For Appalachian hardwoods and the pine region of Oregon the field work was completed during the year, and the data are undergoing analysis. Field studies are under way in the loblolly-shortleaf mills of the South, in the California pine region, and in the Douglas fir region of the Northwest, with particular emphasis on determining the quantity and quality of waste material left on the ground under current logging methods. A closely allied study concerns forest waste through the inefficient operation of small and portable sawmills.

Converting the waste of logging and milling operations to some profitable use is another way to encourage private forestry. Production studies which have been completed on four types of dimension stock operations in the Lake States indicate that with good equipment and careful management industrial cuttings can be profitably manufactured from the poorer and smaller logs that are necessarily a part of any harvesting, and from the edgings and slabs in the sawmill.

SELECTION AND PREPARATION OF MATERIAL

To meet industrial demands for wood of known, uniform properties more effective methods of grading and selection are needed. Among laboratory projects looking to this end is a study, undertaken two years ago, to determine and classify the characteristic defects in lumber from different species and different regions. Last year the study was extended to cover practically all the important softwood species of the country. Data were obtained by visits to 41 mills throughout the softwood-producing regions, the tallying of 400,000 board feet of lumber, and the exact description of every defect occurring in the different grades. While analysis of the data has only begun, conclusions that are of great importance in selecting lumber for particular uses have already been established.

Another study contributing to the better selection of material concerns the differentiation of stock on the basis of density. Analysis of thousands of specimens of mill-run lumber has shown the normal variation of different items and species. Visual means of differentiating between dense and light stock of various species are being developed.

The results of tests of large southern yellow pine and Douglas fir columns were prepared for publication. The relation between the test data, column formulas, and working stresses was presented in a form that, if properly used, will increase the outlet for grades of timber now difficult to market, by making possible the selection of columns that will maintain the correct load without excessive use of material.

The laboratory devoted a large share of its work to studies of moisture and moisture transfer in wood. The reactions of wood to changes in its moisture content form the greatest drawback to its use. A large volume of practical information on seasoning methods will become available in three forth-coming publications—the revised kiln-drying handbook, a general bulletin on the air seasoning of wood, and a bulletin on the kiln-drying of southern pine. Studies to reduce the variability of the moisture content of lumber as it comes from the air seasoning pile or from the dry kiln have been under way for several years. A study on the kiln-drying of Douglas fir was inaugurated during the current year, and further study was devoted to the devising of means for the instantaneous determination of the moisture content of wood.

A basic requirement for improving the seasoning of lumber and reducing the variability in the moisture content of the dry stock is knowledge of the conditions that actually obtain under present industrial practices. Extensive "moisture surveys" to obtain this knowledge were completed during the year, covering both summer and winter conditions. An intensive survey of moisture content and moisture range in a wide variety of items, made during the year in cooperation with the Southern Pine Association, has aided the association in adopting definite moisture specifications in its grading rules.

To learn how dry wood needs to be for interior construction work, or for exterior, or for any other specific purpose, moisture content tests are under way in various regions.

MODIFYING PROPERTIES AND CHARACTERISTICS OF THE MATERIAL

The efficient use of wood demands not only a knowledge of its natural properties and how to adjust use to

them but also in many cases the modification of wood properties to fit the material to specific requirements. Generally this involves the use of accessory materials, such as preservatives, paint, fireproofing and moisture-proofing materials, and glues for veneered and built-up construction. Much has been done to extend and facilitate the use of preservatives in many fields. Studies of wood preservatives are being continued. One new result has been to show that the toxic action of many chemicals upon decay organisms can be roughly predicted from a knowledge of their chemistry. In connection with fireproofing studies a standard test on the inflammability of wood which appears better than those hitherto in public use was developed by the laboratory and informally approved by outside agencies.

Research in the painting of wood seeks both to lengthen the serviceable life of the paint coating and to give greater protection to the wood. Roughly, two-thirds of the softwood lumber cut of the country is found to be of species on which paint fails most rapidly. The principal objective in the continuation of the painting studies is to learn how to get better results on these woods. Much has been learned regarding the relationship between paint failure and board surfaces. The outstanding properties of wood affecting paint service are density and texture, the denser and coarser textured woods being the harder to keep painted satisfactorily.

Studies of the effect of the direction of grain in glued plywood panels, such as those used in doors and table tops, have shown how to lessen warping and cupping. The interrelations of temperature, viscosity, and consistency of glues and the surface conditions of the wood have been worked out and embodied in a recent department bulletin which is the most complete statement of modern wood-gluing principles that has yet appeared.

ADAPTING THE MATERIAL TO SERVICE CONDITIONS

Strength tests of full-size wall panels and other house parts, undertaken by the laboratory in cooperation with the National Lumber Manufacturers' Association, opened attack on the problem of scientific design for the frame house. Great gains from such studies are possible to the owners of houses and small buildings, in the form of better service and satisfaction at less cost. Builders, lumber manufacturers, and timber growers will also benefit. The small amount of testing thus far done points to many practical improvements in design that will result in greater rigidity and storm resistance, and in economy of material.

Ten per cent of the annual cut of lumber in the United States goes into shipping containers. As the population and commerce of the country increase, the demand for container material will expand. The laboratory studies the economical and efficient design of boxes and crates. Transportation hazards as related to the design of shipping containers were studied to learn their relative importance and how either to eliminate them or to design the commodity, the container, or the packing to withstand them. A study of carload shipments of canned foods in fiber boxes showed that about two-thirds of the damage to the boxes occurred in three clearly marked locations in the refrigerator car, and enabled improvements to be made in packing and loading to avoid the damage. This work is to be further continued and expanded.

CONVERSION OF THE MATERIAL INTO PULP PRODUCTS

The manufacture of pulp and paper products from wood is an outstanding field for the utilization of wood waste, little-used species, and second-growth timber of inferior quality. How to utilize a wide variety of species in many different wood-producing regions for a broad range of pulp products is the major research problem which the laboratory is seeking to solve. Success in this endeavor not only will secure improved land use and more complete wood utilization but also will lessen our present dependence upon foreign countries for much of our pulp and paper. The underlying knowledge required concerns the demands made of pulp products in commercial use, the properties of paper, pulp, and wood, and how these are affected by the production processes. Hence the properties of commercial papers of particular grades are being studied and mathematical relationships are being established between paper properties and structure. Certain specific pulp properties, such as particle size and extent of hydration, have been reduced to numerical measurement. These new yardsticks are particularly necessary in seeking to produce commercial mechanical pulp from species other than spruce—a matter of great importance. Shipments of pulpwood are now being

numerically evaluated relative to a wide range of physical and chemical attributes. The effects of duration and temperature of the pulping operation on the yield and quality of pulp in which alkaline reagents are employed have been expressed mathematically for the first time. Thus a few experiments may be made to delineate completely a wide range of pulping conditions by one numerical expression.

The past year has also been one of active progress in applied research. The work on producing strong white papers from southern loblolly pine has been extended to the improvement of the bleaching operation, the duplication of commercial white grades, and the evaluation of various lots of longleaf pine. The duplication of commercial strong, light-colored papers from hardwood sulphite of gum, birch, maple, and aspen is proceeding successfully. The duplication of commercial print, wrapper, and manila papers has been accomplished by the use of the semisulphite process with eastern hemlock, balsam fir, aspen, and black gum. Progress was made in the utilization and disposal of sulphite-mill effluents, often the cause of stream pollution. A rough survey conducted in the Douglas-fir region indicates that enormous amounts of woods and mill waste can be effectively and doubtless profitably utilized by the pulp and paper industry if a satisfactory pulp and paper technique can be worked out. Attention is also being given to the development of a strong white pulp from threshed seed-flax straw. The possibility of developing a commercial feasible process for the utilization of this material now appears promising, owing to the discovery of means of cheaply separating mechanically the very valuable long-bast fiber from the woody shive.

RANGE INVESTIGATIONS

The object of range research is to determine or aid in determining how lands suitable for grazing can be made use of to best advantage, all things considered. Its results, while sought primarily in the interest of the administration of about 90,000,000 acres of national-forest land, are applicable also in varying degree to about 735,000,000 acres of other western range, public and private. Nearly all of this great area of 825,000,000 acres in the West will be used permanently for livestock pasturage. It is essential to learn not only how to maintain and increase its productiveness for this purpose but also how to preserve the watershed values that attach very extensively to the grazing lands, both timbered and untimbered, and both within and without the boundaries of the national forests.

The first appropriation for range research under the provisions of the McSweeney-McNary law was made during the year, bringing the total fund for range research in the Forest Service to $67,000. The added $14,320 will be used for the enlargement of range-research work in Utah, Nevada, and southern Idaho. Studies were continued by the Great Basin Experiment Station, in cooperation with the sheep experiment station at Dubois, Idaho, maintained by the Bureau of Animal Industry, to determine for spring-fall range the best time to begin grazing in the spring and to establish standards for judging when the forage growth is sufficiently advanced to be grazed without loss of range productiveness.

The proper utilization of range brush lands has been something of a moot question. A 5-year study conducted by the Forest Service in southwestern Utah, on ranges where browse constitutes 50 per cent or more of the forage, has proved that both range and livestock suffer when such predominant woody species as oak and service berry are closely grazed, and that carrying capacity should be based primarily on the more palatable vegetation present. A bulletin was prepared setting forth the forage value and requirements of the more important browse species of western range lands. Considerably over a thousand species of shrubby plants occur on these ranges, many of them in abundance, and they differ enormously in palatability and range relationships.

The results of accumulated research in artificial reseeding of western range lands were summarized in a bulletin published during the year. Western range areas having conditions which present knowledge shows to be favorable for reseeding with cultivated species are chiefly small, comparatively level mountain meadows, moist parks, and alluvial bottom lands having superior soil and moisture conditions. Kentucky bluegrass, common bromegrass, and timothy have been successfully established on a number of ranges; white clover has done very well in many moist areas on the west slopes of the Cascades, especially on sheep ranges; and sweetclover, especially in mixture, is valuable where it can be successfully established. About

20 of our native western range plants, chiefly grasses, have also been tried for artificial reseeding, with some promising results, but before much can be done to improve range conditions by their use adequate sources of seed supply must be created. At present slender wheatgrass is the only native western range grass of which the seed is on the market. Considering the enormous number of forage plants the experiments that have as yet been made have not gone very far. The possibilities of native plants, of exotic species, and of plant breeding to develop suitable varieties offer an extensive field for investigations. The encouraging results obtained with mountain bromegrass and with slender and violet wheatgrasses suggest that the cultivation of native forage plants may eventually prove an important means of increasing range productivity.

A circular on the Angora-goat industry, issued last spring by the interdepartmental Angora goat and mohair committee, included information contributed by the Forest Service on management of the range and of goats on the range. Large areas of brush land are better suited to and more profitably utilized by goats than by other classes of livestock, and the Angora-goat industry has expanded enormously within the past few years. Many of the ranges are seriously overgrazed. With better knowledge on the part of growers as to how closely the ranges should be grazed and what management methods should be employed, the prospects of the industry for permanence and further development will be improved.

Studies of various important range grasses gave enlarged knowledge of the best methods of utilizing them and of the degree of intensity and frequency of grazing to which each species can be subjected without impairing its vigor and production of forage.

The need for regulated range use on a very large scale in the more arid parts of the West, to insure favorable watershed conditions as well as range productivity, is only beginning to be understood. Through systematic range research new and highly significant information is being obtained. There is a much closer analogy between the range vegetative cover and the protective cover afforded by the forest than has as yet been recognized in common thought. The same principles apply to both, and the same need exists for measures of public control to prevent destructive practices. This is true not only with regard to the large part of the western range lands now embraced within the national forests but also with regard to much of the outside range, both public and private.

At the Great Basin Experiment Station, in Utah, study of the relationship between range use and watershed conditions was continued. On high mountain watersheds it was found that an increase in the vegetative cover that caused it to occupy 40 per cent of the soil surface as against an earlier 16 per cent reduced the summer surface run-off 55 per cent, and the volume of sediment eroded 56 per cent. Noneroded soil was found to be much more fertile and of greater water-holding capacity than eroded soil, and its vegetation had more leaves, greater stem and leaf length, and a greater production of dry matter with a smaller quantity of water.

Erosion on granitic soils in Idaho is affecting timber, range, mining, agricultural, power, and recreational values. Over 850,000 acres of agricultural land are irrigated by water from watersheds made up of these soils, and over $31,000,000 is invested in irrigation enterprises. Every drop of water from the watersheds is needed to maintain the present irrigation developments. Excessive erosion is taking place, stream flow is diminishing, and reservoirs are seriously silted. The vegetative cover on extensive areas has largely been destroyed through overgrazing. Fire, placer mining, and other influences have contributed to erosion. Research to learn how to retain and improve the vegetative cover on these watersheds is imperative. Recent measurements have disclosed that the Arrowrock Reservoir, in central Idaho, is accumulating an amount of silt that threatens to shorten the life of the reservoir materially. Studies will be made to determine how far the grazing of livestock on the Boise National Forest is responsible, and what corrective measures will be required.

The Tonto National Forest, in Arizona, is one of the principal watersheds of the Salt River irrigation project. The range studies there have shown that the ground cover has broken down seriously in many places, and extensively. The change has been going on for 50 years and has taken place so gradually that it has escaped notice. How much of the original vegetation has disappeared and how extensive is the resulting erosion of the surface soil and silting of the irrigation reservoirs research is now making clear. Fortunately the investigation has indicated also that under

proper protection the original conditions of soil and vegetation can be gradually reestablished. The enormous values in irrigated farm properties and in city real estate and industries far outweigh the values represented in the livestock enterprise dependent upon these watersheds.

In the Salt River valley many crops have been curtailed or eliminated because of a decrease in the water supply. Low water in the Roosevelt Reservoir has reduced the production of electric power. It has been necessary for the water users to borrow heavily from the banks. Serious consequences of erosion are manifested in the condition of the watershed and the unsatisfactory run-off. More than enough water went over the spillways in 1920 to fill the part of the reservoir now occupied by silt. The present irrigation works cost over $21,000,000, and 300,000 acres of land are irrigated. Two hundred and fifty million dollars of farm and urban property are involved; the crops and livestock amount annually in value to $30,000,000. The value of power produced in 1928 was $5,000,000. It is believed that a system of range management can be devised that will adequately protect the soil and ground cover without imposing very great hardships upon the stockmen.

The ranges and watersheds of the Southwest should be studied to determine what kinds of vegetation can be increased; what protection from erosion is afforded by different densities of vegetation on the major soil types; how grazing can favor recovery of vegetation and the rapidity of its reestablishment; how grazing influences run-off and erosion by removal of part of the current vegetative growth, by trampling, and by destruction of the stand; the practicability of artificially reseeding or replanting range areas to check erosion; the practical value of check dams, terracing, and other engineering features under the semidesert conditions of these watersheds; the comparative economic value of the watersheds for supplying irrigation water and for grazing; and the possible advantage of changing from the present yearlong cattle grazing to winter grazing by sheep, for which there is now an intense demand.

EXPENDITURES AND RECEIPTS

The expenditures for all purposes during the fiscal year were as follows:

General administration			$392,453.86
Forestry extension			31,570.38
Research:			
Silvical investigations		$462,539.75	
Forest products investigations		633,072.22	
Range investigations		89,032.16	
Taxation study		61,493.50	
Total			1,246,137.63
Administration, protection, improvement, reforestation and extension of the national forests:			
Administration—			
Timber use	$1,248,367.69		
Grazing use	1,024,103.46		
Fish and game protection	115,470.41		
Recreation and land use	224,548.92		
Examination and administration of power sites for Federal Power Commission and support of its personnel	22,045.00		
Classification, settlement, and claims	71,276.97		
General surveys and maps	165,247.27		
Grazing reconnaissance	117,615.81		
Timber surveys	245,666.79		
Subtotal		3,234,342.32	
Protection—			
Fire protection and detection	1,954,372.07		
Fire suppression	1,532,491.55		
Protection against insects and tree diseases	129,708.83		
Subtotal		3,616,572.45	

Administration, protection, improvement, reforestation and extension of the national forests:—Continued			
Improvement—			
Construction of improvements other than roads, trails, and camp-ground improvements		941,465.58	
Maintenance of improvements other than roads, trails, and camp-ground improvements		677,138.00	
Camp-ground improvements		41,047.00	
Construction and maintenance of roads and trails—			
10 per cent fund under act of Mar. 4, 1913	$419,179.32		
Cooperative construction of roads and trails under act of July 11, 1916	164,942.29		
Federal forest-road construction under act of Feb. 28, 1919	13,263.07		
Forest-development roads and trails under act of Nov. 9, 1921	3,801,944.98		
Forest highways under act of Nov. 9, 1921	5,100,359.88		
Road and trail construction from moneys contributed by cooperating agencies under act of June 30, 1914	1,162,424.22		
Contributed from other appropriations	492,093.09		
Class total (roads)		11,154,206.85	
Subtotal			12,813,857.43
Reforestation—			
Nurseries and tree planting			271,545.11
Extension—			
Land exchanges		129,565.23	
Acquisition under act of Mar. 1, 1911, as amended		1,042,624.62	
Subtotal			1,172,189.85
Total			21,108,507.16
Protection and reforestation of other than national forest lands—			
Tree planting in cooperation with States under act of June 7, 1924			75,187.59
Fire protection in cooperation with States under act of June 7, 1924			1,146,530.82
Protection of Oregon and California grant lands			68,791.00
Total			1,290,509.41
Grand total			24,069,178.4

In addition to the expenditure for land extension itemized above in the entries "land exchanges" and "acquisition under act of March 1, 1911," national-forest timber having an estimated value of $448,240 was cut under agreements involving the acquisition of land and timber through exchange. The cash disbursements recorded under "land exchanges" cover merely the outlay incidental to examining lands offered for exchange and appraising the values involved.

The cash receipts from the national forests were as follows:

From the use of timber	$4,108,595.00
From the use of forage	1,740,289.81
From miscellaneous uses, including the use of land, water-power sites, etc	450,917.05
Total	6,299,801.86

The total is greater by $858,201.14 than that for the previous year. Receipts from timber increased $783,349.84. Grazing receipts were greater by $26,559.66 and miscellaneous receipts by $48,291.64.

In addition to the cash receipts from timber there should be credited the value of the timber cut under specific agreements for effecting land exchanges, estimated at $448,240.

U. S. GOVERNMENT PRINTING OFFICE: 1929

GRAIN FUTURES ADMINISTRATION

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REPORT OF THE CHIEF OF THE BUREAU OF HOME ECONOMICS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF HOME ECONOMICS,
Washington, D. C., September 1, 1929.

SIR: I have the honor to present herewith the report of the Bureau of Home Economics for the fiscal year ended June 30, 1929.

LOUISE STANLEY, *Chief.*

HON. ARTHUR M. HYDE,
Secretary of Agriculture.

This bureau has two quite different, yet overlapping, functions which must be considered in evaluating its work. The first function has been to study practical, everyday, home problems—problems that seem simple enough in themselves but are fundamentally important in the maintenance of the comforts and satisfaction of home living.

In the second place, the bureau is empowered to study the relative utility and economy of agricultural products for food, clothing, and other uses in the home, and to make special suggestion of plans and methods for the more effective utilization of such products in the home. In performing this function the bureau not only contributes toward better home making but makes a more direct contribution to agriculture. In this sense the bureau may be looked upon as a coordinating agency or a connecting link between the materials available on the one hand and a wise use in the home on the other.

This bureau is responsible for such material on home economics being carried out to the States by the various extension specialists and the two agencies in the Government interested in the teaching of home economics. It is looked to as a source of instruction material by State extension agencies, and those interested in the teaching of home economics. Through the various Federal and State agencies and the women's organizations with which it keeps in close touch, the bureau reaches a very large proportion of the 24,000,000 homes.

The bureau is looked to for leadership in the field of home economics research, which is rapidly being developed as the result of the Purnell Act permitting the use of experiment station funds for home economics research. Nearly all of the States are now using a portion of this fund for such studies. This throws additional responsibility upon the department, and there is need for supervision and coordination in this work. This is more necessary in home economics than in other fields because the problems are more similar from State to State, and the workers are newer in research. The work of the bureau with the States has saved, in the prevention of useless experimentation and better coordination of endeavor, sums of money many times that expended in this effort.

Development of research in a new field like home economics needs the development of new methods. New pieces of equipment have been tested. Information on methods and equipment has been made available to the States. Schedules of economic studies have been furnished with detailed directions for editing and summarizing the data as they are collected, and in some cases new workers have come into the laboratories of this bureau for definite instruction in details of method.

There are two agencies in the Government interested in the teaching of home economics—the Bureau of Education, and the Federal Board for Vocational Education. In the former there is a specialist in home economics education who is engaged in studies on organization and methods of teaching home economics. Associated with her in the Department of the Interior is a specialist in home economics who

has supervision of home economics in the Indian schools. This bureau has maintained cooperation with both these units, and a member of its staff has served on the committee for preparation of menus for use in the Indian schools. The home economics section of the Federal Board for Vocational Education has charge of the administration of the home economics portion of the fund made available to the States through the Hughes Act, and recently increased by the passage of the Mendel-Reed Act. Various publications of the two above groups are concerned primarily with methods, equipment, or organization of material for teaching. While there is no official connection between the Bureau of Home Economics and these agencies, the latter use the results of the bureau's research as source material, and in so far as possible we attempt to put the material in the form in which it will be the most useful to them.

Cooperative relations are maintained with other Government organizations. The work of this bureau relates very closely to certain aspects of that of the Children's Bureau and the Public Health Service. The line of separation is generally considered to be that the Bureau of Home Economics is responsible for problems having to do with the normal child. When the services of a pediatrician or social agency are required, the study may be a cooperative one or handled entirely by one of the other agencies. In the same way the problems of normal nutrition fall in the field of this bureau, leaving the therapeutic and pathological aspects of the subject to be handled only in cooperation with the Public Health Service. Similar cooperation will be needed in studies regarding the relation of clothing to health.

The bureau has been very fortunate during the past year and a half in having the opportunity to work with certain representatives of governmental organizations on the study of problems related to child care and training. The facilities of the Washington Child Research Center have been put at its disposal for studies in nutrition and clothing for children. Since various agencies are demanding material on child training for use in their extension activities, the close cooperation with the Child Research Center makes it possible for this to be provided as soon as a specialist can be made available.

The Bureau of Home Economics has gradually assembled a staff of 60 workers, of whom 30 are specialists in professional service, working now under three divisions: Economics, foods and nutrition, and textiles and clothing. The duties of these specialists are (1) to keep in touch with the scientific data available from Government and other research agencies which can be applied in their special field, (2) to interpret these and make their application to home problems, (3) to direct certain studies being conducted by other agencies so they will be of greater help in the solution of home problems, and (4) to initiate studies in parts of this field not being covered by any other agencies. In addition, members of the staff have the responsibility of keeping in touch with various welfare groups through which the accumulated information can be disseminated.

The first need was to work toward the establishment of fundamentally sound standards for food, clothing, and housing—the three important elements in the material side of home life, which would direct the wise use of our agricultural products in the home and at the same time help in the establishment of the basic facts for any educational program in home making.

National prosperity and lack of unemployment do not alone guarantee a higher standard of living to the people of any nation. Better wages must be directed into wise channels of expenditure if they are to be reflected in family and individual well-being. Standards are essential for the education of the consumer in the wise use of the goods available. The wider the opportunity for choice the greater the necessity for this education. Not only will such an educational program add to the physical well-being and mental satisfaction of the individual, but also, through the better adjustment of production and distribution which it would make possible, would contribute to the social and economic stability of the country as a whole.

The requirements for the material side of the home are considered first, not because of their greater relative importance, but because they can be measured more exactly and because they furnish the necessary foundation upon which the less tangible objectives of home life may be built. Time, money, and certain material perquisites should be spent to best advantage for family living. From the national point of view there must be wise direction of production and dis-

tribution of goods and services in order that "comfort and welfare" may be available to as many of these homes as possible.

ECONOMIC STUDIES

Economic studies must form the center of such a program, adjusting expenditure of time and material resources to the different needs of the family, balancing the various demands, and expressing them in terms of household budgets and time schedules. All this demands standards set up in objective terms showing the content of family living and how the time is spent against which detailed cost-of-living accounts, use of time studies, and results can be checked. To this end the economics division of the bureau has concerned itself chiefly with two sets of problems.

Cost-of-living studies have been made and the food and clothing figures analyzed to find the content of living. Figures collected by survey records will be compared with those obtained from actual household accounts to be used later as a basis for budget recommendations. Other Government agencies have been interested in cost-of-living studies, but no other Government agency has analyzed these expenditures and measured them against such standards as are now available to determine whether or not the money is being expended so as to promote the standard of living which should be maintained. Such standards need to be established in all lines of family expenditure. This can only be done by specialists who can analyze expenditures critically. Specialists in different lines of home making are available in this bureau. It is the hope that when in the future cost-of-living studies are undertaken by other Government agencies cooperative arrangements can be entered into so they can be analyzed by specialists and the content of living determined.

Time studies have been undertaken to determine the time spent in household tasks and to evaluate the economic return from time spent in various aspects of household production. These will form the basis for recommended time schedules and household-labor studies of different types.

COSTS AND STANDARDS OF LIVING

METHODS OF COLLECTING DATA ON FAMILY EXPENDITURES

The importance of studies of family expenditures has been intensified during the last few years by the continued increase in the national income and the consequent changes in the demand made for various products by different groups of consumers.

Before new studies in this field are undertaken, either by this bureau or by other research agencies, information is urgently needed as to the accuracy used in collecting the data. The survey or schedule method, which is most often used, relies upon the housewife's memory of the expenditures made by her family during the preceding year. It has been recognized that such estimates probably involve more error than appears with the account method, where an actual record of expenditures is made daily by the housewife during the year. But the great difficulty of getting a large number of housewives to keep complete yearly accounts has discouraged the use of this method. No information has been available, however, as to the relative accuracy of the two methods or as to the items in the family budget which are most affected.

A study has therefore been made comparing the figures obtained by the schedule method with yearly accounts from the same families. The data were collected during 1926–1928, 44 farm families and 24 business and professional families sending in weekly records of expenditures for 52 consecutive weeks. At the end of the year a field agent visited each family and obtained schedule estimates of expenditures for the same period. Since the keeping of the accounts might improve the housewife's memory in giving the schedule figures, even though she herself did not summarize her accounts, control schedules were obtained from 22 of the farm families keeping accounts before the accounts were started, covering the preceding year, and from 41 additional farm families not keeping accounts, who were selected for purposes of comparison.

During the past year this material has been analyzed, and a report is now in preparation. This will include a detailed analysis of the figures on food consumption, comparing not only the quantities of the various foodstuffs consumed as shown by the two methods, but also the nutritive value derived from them.

OTHER STUDIES OF FAMILY EXPENDITURES

Reports are also in preparation on two other studies of family expendi-

tures started in 1927–28. One study covers 190 business and professional families from various parts of the United States—a type of family almost entirely neglected in previous standard-of-living studies. The results as to the cost of children and the cost of medical care in these middle-class homes are of special interest. From 66 of these families yearly accounts were obtained from weekly reports sent in to the bureau, and from the remainder yearly schedules were obtained by a field agent.

The other study deals with families receiving mothers' pensions. Through the Bureau of Public Welfare of the District of Columbia, Division of Mothers' Pensions, complete yearly accounts were secured from 45 families. The analysis of these data throws valuable light on the adequacy of the living available to these mothers and their children, and on the wisdom with which the pension is expended.

CLOTHING EXPENDITURES OF FARM FAMILIES

The report of the study of clothing expenditures of 2,459 farm families in 10 States is awaiting final tabulation. The data used in this study were obtained by the schedule method, as part of the larger study of the farmer's standard of living made in cooperation with the Bureau of Agricultural Economics.

TRENDS IN COTTON CONSUMPTION

It has been evident during the past few years that consumers are shifting from cotton to silk or rayon for certain articles of clothing and of household furnishings. The extent of these changes, however, or the types of articles most affected, has not been known. A survey was therefore started in the summer of 1927 to obtain information on these points. Through the cooperation of teachers in colleges and universities, extension workers, and club women, over 1,000 questionnaires were filled in by men and women representing all sections of the country. This material has been analyzed and a report printed in one of the regular series of the department.

HOUSEHOLD PRODUCTION

TIME STUDIES

The study of the use of time by home makers is also being brought to a close. During the past year the figures from weekly time records of 1,100 home makers in 36 States have been tabulated, and two preliminary reports have been prepared. Special reports are now being written on the help received by home makers from various members of the family and from paid workers, on the equipment used in these homes and its effect upon the time spent on various tasks, and on the use of leisure by farm women. The complete report of this study will appear during the coming year and comparisons will be made with the time records from about 1,000 additional home makers obtained by research workers in Oregon, Washington, Rhode Island, and South Dakota who are cooperating in the study under Purnell funds.

WHO DOES THE LAUNDRY?

As a part of the study of the changing uses of textile fibers, information was obtained from 822 housewives and 168 self-supporting women as to how their laundering was being done—whether by themselves or another member of the family, by a paid laundress, or by a public laundry. A report of this inquiry, showing the practice in farm homes and in city homes with varying incomes, appeared in October, and a more detailed report is now in manuscript.

EMPLOYER–EMPLOYEE RELATIONSHIPS IN THE HOME

In over a million homes of the country, paid workers are employed to assist in the work of the household. The maladjustment existing in this important industry is so general and so acute that it is known to every man, woman, and child as "the servant problem." In October of the past year the bureau cooperated with the Women's Bureau of the Department of Labor and the industrial department of the Young Women's Christian Association in calling a 2-day conference to discuss this problem, from the standpoints of the employer, the employee, and the public. As a result of this conference, a permanent national committee on employer-employee relationships in the home was established, with two members of the bureau, a member of the Women's Bureau, a member of the Federal Board for Vocational Education, and representatives of various interested groups on the executive committee. The

functions of the committee were stated as follows:

To learn what is now being done and has been done in this field, and to evaluate the experience thus gathered, considering such problems as standards of employment, education, placement and follow-up legislation, and organization.

To formulate a program of research and experimentation.

To seek the cooperation of agencies working in this field in carrying out this program.

To consider the desirability and possibility of securing funds for conducting this work and for carrying on additional study and experimentation.

During recent months the committee has proceeded with the formulation of a research program and with a survey of the existing activities in this field. In this work, and especially in the research program, the bureau has assisted.

FOODS AND NUTRITION

Food is one of the first considerations in any standard of living. The economic value of the agencies concerned in food production, manufacture, and distribution, as well as the close relation of food to health and physical well-being, emphasizes the importance of a more staple food production and distribution program based on nutritional requirements. Flexible food standards, capable of being adjusted to our increasing knowledge of nutrition, have been established.

The Foods and Nutrition Division of the bureau has been largely concerned with the development of the necessary information to establish these standards in practice. This has involved (1) collection and publication of data on food composition; (2) research in the vitamin content of foods and compilation of results and literature references on the occurrence of vitamins in all food materials so far studied, together with bibliographical references on technic; (3) dietary studies among families and institutions and the development of methodology for making such studies; and (4) food-utilization studies.

PROXIMATE COMPOSITION OF FOODS

Research on the chemical composition of fresh vegetables has followed the work on fresh fruits and fruit juices published last year. From the standpoint of dietary calculations, there was more urgent need for figures on vegetables, probably, than for any other class of foods. Since the last compilation on proximate composition of foods by W. O. Atwater was issued by the department in 1906, no new data on this important class of foods have been assembled in an available form, and analyses had not then been made of many vegetables on our markets to-day. A few new analyses have been made at the instigation of this bureau, and many other data, published and unpublished, have been collected and studied for the purpose of providing tables that will furnish reliable information on about 95 vegetables. These tables are now nearing completion and are being reviewed by various horticulturists and marketing specialists.

VITAMIN CONTENT OF FOODS

The examination of foods to determine their vitamin content has been continued in the nutrition laboratories in conjunction with studies designed to improve the technic used in these assays.

Recent work on vitamin B in the laboratories of this country, as well as elsewhere, has clearly shown that it must be regarded as comprising two separate factors having distinctly different physical and chemical properties. One factor has heat-labile and antineuritic properties and the other has heat-stable and pellagra-preventive properties. The recognition of the "dual nature of vitamin B" has made it necessary to devise methods for detecting the presence of these two factors in foods. Tentative methods have been described by workers in other laboratories, and the more promising of these have been tried in the laboratory of this bureau. Results obtained during the course of this study showed that rice polishings are a good source of the antineuritic vitamin and contain but a small amount of the pellagra-preventive vitamin. Wheat germ and yeast are excellent sources of both factors, whereas white corn contains an abundance of the former and a very small amount of the latter.

The determination of the vitamin content of watermelon is in progress.

Recently several distributors of Japan green tea have described their product as a valuable source of vitamin C. Inasmuch as vitamin C is easily destroyed, especially when foods are dried, their claims seemed unlikely. For this reason the infusions made from four samples of tea have been assayed, with the result that no appreciable amount of vitamin C could be detected in any of the samples.

The practice of sending rats to those requesting them for use in dem-

onstration work has been continued. A greater number of animals was sent to teachers and demonstration agents than last year, and it was not possible to comply with all the requests.

The series of nine charts containing photographs of rats or guinea pigs that had been fed a diet deficient in one or another of the well-known food constituents are now in press, and will be available by purchase, at a nominal sum, from the Superintendent of Documents, Government Printing Office.

Through a cooperative arrangement with the Office of Experiment Stations, a comprehensive summary of data on vitamins in foods has been made and is now in press. In addition to occurrence tables for vitamins A, B, and C, there are included some 400 literature references on the occurrence of these and the other vitamins so far differentiated and on technic in vitamin research. The illustrations for this bulletin are of rats and guinea pigs from the laboratories of this bureau. They exhibit symptoms typical of vitamin deficiency and show normal nutrition resulting from adequate diet. These vitamin tables used in conjunction with the figures on proximate composition will give more complete information on the food value of a great variety of foods common in the American dietary than has been available heretofore from Government sources.

DIETARY STUDIES

Dietary studies have been made to determine variations in existing food habits from the requirements usually recognized as essential for good nutrition. This work has been carried on in close cooperation with the cost-of-living studies, since in food there have been set up definite standards against which the content of living can be measured. During the past year a technical bulletin describing a new short-cut method of calculating the various nutrients in the diet has been published. By this method a time saving of 40 per cent in making dietary calculations can be effected, a matter not only of great importance to the work being done in this bureau but in States conducting similar studies under Purnell funds.

The data on the food consumption of farm families have been further analyzed and are now being prepared for publication. In connection with this and some studies being made on the food habits of professional and business families, data have been assembled comparing the schedule with the survey method of collecting information on food habits, this being a part of the study mentioned under cost of living. The material on food is being given intensive study.

The data on the quantity and cost of food served to college students, which have been collected in cooperation with agencies in several States, are now in press. A study of food consumption in children's institutions is nearing completion. Data collected by the Merrill-Palmer School, Detroit, Mich., on dietary habits in Grosse Ile, a very restricted community near Detroit, have been made available to this bureau for analysis.

At the request of the home demonstration manager and the home demonstration agent in a county in South Carolina, the bureau entered into cooperative arrangements for the study of the dietary habits of the families affected with pellagra. Studies were made both before and after the season during which pellagra becomes most active. With a limited number of families protective foods were introduced in order to determine the effect of these on the incidence of pellagra. This work has been done in close cooperation with the local health authorities and is now being summarized.

FOOD UTILIZATION

Food-utilization studies have been made to test the quality of food produced under varying conditions, to determine more satisfactory uses for well-known foods, and to find uses for new foods brought to our attention by producing groups. Special attention has been given to the possible utilization of materials now regarded as by-products. These studies are important from the economic point of view in promoting the wise utilization of agricultural products and in making possible the proper feeding of groups at different income levels.

PALATABILITY OF MEAT

The most detailed experiment which the bureau has undertaken in food utilization has been the project in cooperation with the Bureau of Animal Industry and some 20 State agricultural experiment stations on the palatability of meat. During the past year there have been cooked in our laboratory, according to the standard methods, and tested for palatability 142 rib roasts of beef, 557 legs of lamb, 20 whole fresh hams, 47 half fresh hams, and 38 pork loins. These have been sent in from 16 States.

A limited amount of experimental work has been done toward determining what comparative effects are produced on meat by increasing the roasting temperature above that specified in the standard directions for cooking meat for palatability tests. The practical reason for this study is to find out whether or not the long, slow cooking of the standard methods has the effect of obscuring in a series of meat samples differences that would have been noticeable if the same samples had been cooked according to the household directions given in popular leaflets issued in connection with the work of the project. Pairs of cuts were used in these experiments. One member of the pair was cooked according to the standard directions, and the other according to household directions. The samples were all judged by the palatability committee. Data have been assembled for 16 pairs of legs of lamb and 30 pairs of beef rib roasts, but have not been completely analyzed.

Work was continued on the roasting of chicken for the purpose of setting up a standard method of cooking chicken for palatability tests. Thermo-couples and mercury thermometers were used to determine meat temperatures. No satisfactory way has been found so far for determining the end point of cooking chickens in palatability tests. Some progress has been made, however, on this complicated problem.

Cooking experiments were carried on to furnish the basis of household recipes published in the revised beef leaflet, in the leaflet on eggs, and in the fresh pork leaflet.

UTILIZATION OF NEW FOODS AND BY-PRODUCTS

In cooperation with the Bureau of Biological Survey, studies have been made of methods of preparing reindeer and domestic rabbit meat. These data are to be published in leaflet form.

Comparison of the cooking quality of rice of different varieties and from different sources has been made with a view particularly to finding a native variety that will prove satisfactory under the conditions of processing required in making soup in commercial quantities. Considerable further study on this problem is needed.

In the study of the use of by-products, special attention has been paid during the past year to rice polishings and wheat germ. Rice polishings is a rich source of vitamin F and wheat germ is, after yeast, one of the most valuable sources we have of vitamins F and G. Rice polishings and wheat germ are generally sold as by-products from the mills, partly because they spoil rather readily if untreated and therefore can not well be left on the rice or in the flour without causing its deterioration. The bureau has shown that these may be preserved by a short heating process, followed by sealing, and has worked out palatable recipes for their use. It is believed that they both furnish valuable and cheap additions of minerals and at least one of the vitamins for diets likely to be restricted in these important factors, and that a solution of the whole-wheat bread controversy may be found by preserving the wheat germ separately and adding it to the white flour at the time of bread making.

Inasmuch as palatability is an important factor in determining the amount of food consumed, recipes are tested and new ones worked out for home and institutional use in order to develop a higher standard of food preparation. It would be difficult to estimate the waste each year due to unpalatable food preparation, loss of nutritive constituents, and waste of time through unnecessarily complicated methods of preparation. Only by scientific study will any standards for food preparation be established. Seventy-eight tested recipes have been contributed to the radio releases issued by the department.

TEXTILES AND CLOTHING

In the division of textiles and clothing studies are being developed from the same points of view. The direction of choice, use, and care of clothing and the setting up of clothing standards were the first points of attack. It is necessary in the matter of clothing, as in the matter of foods, for educational agencies to work closely with the industries, presenting to them the viewpoint of the consumer and working with them in the development of types of materials and garments which are more directly suited to the needs of the consumer. The small amount of work we have been able to do indicates that the producer is interested in having this help and is quite willing to give adequate cooperation and to do all in his power to develop his material to this end.

During the past few years producers and manufacturers of this country have made use of style in an unfortunate way to increase sales. In most

cases emphasis has been laid on change rather than on real value. These rapidly changing styles have resulted in enormous economic waste, and an increasing number of both producers and consumers want more fundamental standards established. The work of the bureau on textile materials and clothing has therefore been concerned largely with investigations undertaken in an effort to help bring about a more economical and satisfactory selection and utilization of textile goods, especially those of importance in the agricultural program of the country. In addition, cooperation has been given to national organizations that are attempting to set up quality specifications on such materials as sheeting, blankets, and silk goods in order to give the consumer information upon which to base an intelligent selection.

CHILDREN'S CLOTHING

The utilization of cotton and wool in children's clothing has been given particular attention. In this work modern developments in child health and child training have been taken into consideration and special emphasis laid upon the desirability of hygienic clothing.

Suits for small boys have been designed that are in accord with present theories on child training and are more practical than the suits now on the market from the standpoint of ease of cleaning and of manipulation by the child. A leaflet describing these is in press.

A hot-weather dress for the little girl has been devised which eliminates the necessity of an underwaist and provides a comfortable 2-piece garment for summer wear. In cooperation with the Washington Child Research Center, a self-help bib was developed which can be put on and taken off by preschool children.

Protective suits to be worn by children in cold and rainy weather have also been devised in cooperation with nursery-school specialists, and descriptions and illustrations will be issued in leaflet form. These are garments that will protect the child so that outdoor play will be possible even in inclement weather. They are also so designed that the child can put them on and take them off without adult assistance. In cooperation with the Cotton-Textile Institute and the Wool Institute, commercial fabrics have been studied in an effort to ascertain which are most suitable for these suits. Such properties as heat insulation, air permeability, tensile strength, and weight are being determined, and it is hoped that as a result specifications can be set up for lightweight materials of suitable construction.

WEARING QUALITIES OF COTTON FABRICS

The reaction to wear of 500 sheets of known history, discarded by a Washington hotel, was determined and reported on. The study showed that a sheet tends to wear out where the shoulders of the person occupying the bed rub against it. In almost every worn place, whether threadbare or torn, the filling yarn had given away before the warp yarn. Many of the sheets showed wear down the center lengthwise fold. These results are indicative of improvements that might be made in the construction of sheets in order to increase their wearing properties. This study is being followed by an investigation of the durability of sheeting made of cotton of known grade and character. The material is being woven in cooperation with the Bureau of Agricultural Economics and the sheets will be used and laundered in a Washington hotel.

LAUNDERING AND SIZING OF FABRICS

The studies on laundering and sizing of cotton fabrics have been continued. A technical bulletin has been published reporting the part of the work dealing with a method for measuring the stiffness of sized fabrics and the stiffness produced in fabrics by different starches and starch mixtures. This study has been extended to include more uncommon starches, such as dasheen and canna, and the relation of penetrability of the starch to the stiffness of the fabric is being given particular attention.

Methods developed in our laboratories for artificially soiling materials to be used in experimental studies and for determining the soil removed by various laundry processes is described in a paper now awaiting publication in a research journal. The influence of ironing on cotton fabrics of different construction and containing cotton of various grades and character is being investigated in connection with a project in which the Bureaus of Agricultural Economics and Home Economics are cooperating. An experimental household ironer has been developed in cooperation with a manufacturer and will be used not only to learn the effect of different temperatures and pressures employed in ironing upon cotton

fabrics, but also to determine the best temperatures and pressures for different types of materials. Color changes and the effect on the gloss and tensile strength of the fabrics are some of the points being studied. This investigation has also involved a consideration of the chemical changes that take place in cotton when heated under pressure, and preliminary studies have been made in this field.

HYGIENIC ASPECTS

In order to bring available information within the reach of investigators working on the hygienic aspects of clothing, a bibliography of 1,180 references to scientific and popular literature published in English, French, and German has been compiled and transmitted for publication.

A preliminary study has been made of the effect of different fabrics on the skin temperature of individuals. This will be followed, it is hoped, by other investigations on the physiological effect of clothing that can be used as a basis for recommendations for the selection of hygienic garments to be worn under different climatic conditions.

OTHER STUDIES NEEDED

HOUSING AND EQUIPMENT

A division for study of housing and equipment has not been formed, but problems of kitchen planning, planning the house for convenience, and home refrigeration have been studied.

Housing standards and methods of meeting them need further study. The home economist has cooperated with Better Homes in America in an educational program. Research is needed, however, to develop and study the problems in both housing and equipment which arise in connection with the educational work of these organizations. New building materials are being developed. These should be tried out and tested. This should be undertaken in cooperation with other Government and welfare agencies, but planned so as to add to their programs those factors which can come only from those who see the problem from the point of view of carrying out the work of the home. Houses are being planned without due thought as to whether they will make possible efficient housekeeping. While housekeeping is not an end in itself, it is an essential background for good home making.

Housing is important not only from the point of view of cost and efficiency, but also from the point of view of health and the aesthetic development of the individual. Housing studies can not be separated from the study of equipment, the kinds available, the cost of the equipment in the individual home, the cost of using equipment cooperatively as compared with the cost of having work done outside by either commercial or cooperative agencies.

There is need for studying multiple housing, both the grouping of the individual homes around some centralized agencies for taking care of certain necessary parts of housekeeping and apartments which can combine some of the advantages of the separated home with those of a multiple dwelling. Among such advantages might be mentioned centralized heating, centralized service for cleaning, some centralized food preparation, even extending so far as the central dining room for those who care for service of this type.

The home maker must bring all of these material aspects together, applying the results of economic studies and balancing them against each other so as to form the physical background of the home. At the same time she must see that the housekeeping does not become an end in itself but serves only as a means for the development of the higher values of home life. The home maker directs not only the expenditure of money but the expenditure of time in the home. In cooperation with the other members of the family, she must plan and direct the recreation of the whole group and the training of the children in the home. The wise use of the material aspect of housekeeping may be directed so as to influence the training of the children in the home and the setting up of a home environment which will make for maximum development of all.

HOME RELATIONSHIPS

Some homes succeed, some do not. No two people would agree upon the details which make for perfect relationships in family life, and no one description would cover them. Unquestionably these relationships will take different forms, depending upon the individuals concerned, and family life must be a reflection of their developing personalities. There is a growing insistence, however, that studies be made to find out some of the elements which enter into success-

ful family life. No home to-day can withstand changes brought about by the onward march of our social and industrial life unless it adjusts to them. The home must be studied in the light of these changes, and particularly to see how it can be organized so as to meet the demand for self-expression and freedom without the sacrifice of present values. The home has at its command to-day resources which, if wisely used, promise to enrich life, to give fuller expression to individual personality and a better rounded development for all the members of the family than ever before.

CHILD DEVELOPMENT

The United States is pledged to the policy of giving to every child a chance to develop to the fullest his potential capacities. Such provision can be secured only by the cooperative effort of home makers and the agencies interested in bettering conditions for child life. Experts from many fields, pediatricians, nutritionists, psychologists, and a large group of social and educational agencies are making contributions to our knowledge of the proper care of the young child, but their investigation and teaching have little effect upon actual conditions surrounding our young children until the home and the parents in the home understand and apply them.

RECREATION

The home must direct the use of leisure time. Industrial efficiency is bringing to a large group increased leisure. Application of the same principles of efficiency to agriculture and home making should make possible increasing leisure for still larger numbers. It is essential that some plan be worked out by means of which home makers may direct the use of leisure time into wholesome recreational activities which will add to the development of the individual. Unless this is done, increased leisure is going to prove a menace to our civilization.

INSTITUTIONAL HOUSEKEEPING

Home economics is ordinarily looked upon as being concerned only with home making. It also has a contribution to make to institutional life and Government housekeeping. No beginning has been made as yet in applying there some of the standards we are commencing to apply in private homes, even on the material side. The application of principles of efficient management to institutions should make possible a higher standard of care at lower cost. Moreover, our institutions, whether they are eleemosynary or punitive, should not be looked upon as providing just physical care, but should be so organized that they will turn back the individuals into the community better prepared mentally and spiritually, as well as physically, to carry on. The institutions might well be used as a means of obtaining data on some of the facts which must be brought together and also as training schools for home making as applied to larger units.

LIBRARY

The work of the Bureau of Home Economics library has continued to increase. The aim of the library is to make the literature on home economics and related subjects easily accessible to the bureau staff and to visiting home economics workers. This is done by indexing the current information for the card catalogue, by acquiring new books and periodicals at the request of the staff, and by borrowing the desired books and periodicals from the Library of Congress or other libraries. This year 3,251 cards were added to the general catalogue. A special textile and clothing index of 10,000 cards is being revised.

The library has prepared a number of lists of references on specific subjects in connection with the general correspondence of the bureau and at the request of other libraries or visiting scientists. Among those from outside of the department who made use of the library during the past year were scientific workers from Arkansas, Minnesota, Nevada, Missouri, Virginia, and Maryland, some of whom remained for several weeks. As the number of workers in the bureau increased so did the number of loans from the library. At the request of the staff 55 new periodicals were added to those already received, and the total circulation of periodicals increased by 1,736.

PUBLICATIONS, INFORMATION, AND EXHIBIT SERVICE

Bulletins in the regular series of the department, articles in technical and popular periodicals, news and radio releases have continued as in previous

years to be the chief means of disseminating the results of research conducted by the bureau.

The following seven contributions from this bureau have been printed by the department during the past fiscal year, and six others have been transmitted for publication:

Short method of calculating energy, protein, calcium, phosphorus, and iron in the diet. Technical Bulletin 105.
Stiffness in fabrics produced by different starches and starch mixtures, and a quantitative method for evaluating stiffness. Technical Bulletin 108.
Proximate composition of fresh fruits. Circular 50.
Vitamins in food materials. Circular 84. (In press.)
The changing uses of textile fibers in clothing and household articles. Miscellaneous Publication 31.
Cooking beef according to the cut. (Revised.) Leaflet 17.
Eggs at any meal. Leaflet 39.
Good food habits for children. Leaflet 42.
Pork in preferred ways. Leaflet 45. (In press.)
Reindeer recipes. Leaflet 48. (In press.)
Ice creams frozen without stirring. Leaflet 49. (In press.)
Suits for the small boy. Leaflet 52. (In press.)
Nutrition charts. Series of nine, 16 by 20 inches in size, depicting results of feeding experiments on white rats and guinea pigs. (In press.)

In addition to these publications belonging to the regular series of the department, there were contributed to the Yearbook of Agriculture, 1928, of the department eight articles covering as many different phases of the economic, textile, clothing, and food and nutrition research. Scientific and popular articles to the number of 250 were contributed to professional journals, magazines, and newspapers, and a mass of source material on the various phases of the work of the bureau was assembled in response to the request of special writers.

As during the two previous years, the menus and recipes for the Housekeepers' Chats have been furnished to the radio service, this year a total of 140 menus and 78 new recipes. Topics and material for the chats have been furnished regularly as a part of the cooperative arrangement, and various members of the staff have given talks as a part of the noon-hour programs broadcast over an extensive network.

A series of 60 lantern slides with accompanying lecture notes entitled "Come Into the Kitchen" was prepared for distribution through the Office of Cooperative Extension Work.

A 24-slide balopticon in colors entitled "Cooking Lamb from Tip to Tail" was arranged from photographs of meats prepared in our laboratories as part of the department exhibit at the 1928 International Livestock Show in Chicago.

Our general correspondence has increased 50 per cent, and during the year we have accordingly answered 15,000 letters asking for information or publications on a wide range of home-economics topics.

U. S. GOVERNMENT PRINTING OFFICE: 1929

For Release to Morning Papers of December 14, 1929

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REPORT OF THE DIRECTOR OF INFORMATION

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF INFORMATION,
Washington, D. C., August 31, 1929.

SIR: I have the honor to present herewith the report of the Office of Information for the fiscal year ended June 30, 1929.

M. S. EISENHOWER, *Director.*

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

EDUCATIONAL ASPECTS

The laws which established the United States Department of Agriculture place upon it the duty of collecting and diffusing useful agricultural information. In recent years there has been a decided increase in the fact-finding machinery of the department. This has called for greater responsibility on the part of the teaching agencies; particularly, the Extension Service and the Office of Information. The latter, by means of publications and its relations with the press and commercial radio stations, is engaged daily in making available to the public accurate information on agriculture. In keeping with the expanded fact-finding and regulatory program of the department, the Office of Information during 1929 increased its educational activities to the fullest extent possible under current appropriations.

The value of the scientific research performed by the Department of Agriculture depends largely on its results being placed in the hands of the public. Research can not be conducted efficiently in closed compartments by scientists equipped with laboratory facilities but lacking the means of communication with coworkers and with the public. Research in the dark involves wasteful duplication, and languishes for want of the stimulus that discovery in one field should exercise on inquiry in other fields. Lacking prompt publication of research results, scientific investigation drags, and at the same time fails to exert the influence it might on contemporary practice in the agricultural and industrial arts. One of the best means of correlating research work itself is to keep all research workers informed of progress in the various fields of scientific endeavor.

DEPARTMENT WORK IS EDUCATIONAL

In a sense all the work of the United States Department of Agriculture is educational. Scientific research is conducted to lay a foundation for education in the production and use of agricultural commodities. Educational rather than punitive methods predominate in the department's law-enforcement activities. The department is adding constantly to the body of relatively exact, verifiable, and communicable knowledge.

COSTS LESS THAN 1 PER CENT

In industrial production it is not at all unusual for publicity costs to amount to 5 per cent of the annual budget. It is therefore pertinent to note that the appropriation for printing all our forms, periodicals, bulletins, for all purchases of machinery, for a tremendous amount of mimeographing, for the salaries of editors

and other employees, amounts only to about 0.8 per cent of the department's total appropriation. This indicates that the function of disseminating information—made imperative by the organic act of the department—is performed economically. If funds for job work and other work performed by this office for other than strictly informational purposes are deducted, the percentage of funds used for the principal function of the office is much less.

The Office of Information is in no wise a publicity agency in the usual sense of that term. Its purpose is not to acquire prestige for itself nor for the department as a whole, nor to "sell" the department to the public, nor to advertise the achievements of department workers, but to make public the results of the department's manifold activities. It was said in Congress in 1914, when the Smith-Lever Act was in preparation, that agricultural knowledge then accumulated in the department was fully 25 years in advance of average farm practice. The disparity is not so great to-day, but a disparity nevertheless exists. To help in removing it is the chief duty of the Office of Information.

A program was outlined during 1929 which should eventually increase the effectiveness of the department's educational work. That program is directed toward the establishment of a closely knit cooperative arrangement with other institutions and organizations which are also endeavoring to aid the farmer by placing in his hands useful facts about farming. These agencies include the agricultural colleges and experiment stations, farm organizations, publishers, and others. Agricultural research in the experiment stations and in this department is coordinated. State and Federal extension activities are coordinated. Information specialists, to reach their greatest usefulness, should coordinate their State and Federal activities in radio, press, and publishing work. The contemplated program does not in any way attempt to make this coordination binding by agreement. On the other hand, the mutual benefits derived from a closer understanding of related problems should cause such cooperative efforts to increase steadily.

It is not possible to show exactly the results of the informational work done during 1929, since educational values can not be measured in dollars and cents. However, the work itself can be reviewed. The results may answer four main questions as to the effectiveness of the methods used:

(1) Is the knowledge in the department made available to the public adequately?

(2) Does it reach those for whom it is intended?

(3) Is it used by those who receive it?

(4) Can the present program be improved?

PERSONNEL

During the fiscal year 1929 there were several changes in the personnel of the Office of Information. Nelson Antrim Crawford resigned as Director of Information on November 30, 1928, and M. S. Eisenhower, administrative assistant to the Secretary, was appointed director on December 1. On July 16, 1928, L. J. Haynes, who had been chief of publications for some years, was transferred to the press service to do special work in the preparation of graphic material for the press, and M. C. Merrill, editorial chief of publications, was appointed acting chief of publications. On December 29, 1928, Doctor Merrill was appointed chief, and Frank D. Smith was appointed assistant chief of publications. The former is in general charge of the division, with particular supervision over the business and editorial phases of the work, and the latter supervises all operations, including printing, duplicating, mailing, and distribution. Later E. C. Powell, senior editor, was placed in charge of the editorial section, and George L. Sherman was appointed in charge of the printing section. Miss Carolyn Whitlock was appointed bibliographical editor upon the resignation of Mrs. Louise R. Joseph, October 31, 1928. On April 30, 1929, Mr. Haynes resigned from the press service. Civil-service examinations were announced to fill this position, an editorial position in the Food, Drug, and Insecticide Administration, and two positions in the radio service; the surprisingly few applications received indicated strongly that the entrance salary, $2,900, does not offer much attraction for people with the high qualifications demanded.

During the year the personnel and business office, formerly a part of the division of publications, was transferred to the director's immediate office. The associate editor of the Year-

book was made assistant to the Director of Information.

The number of employees remained practically stationary, at 192. Nineteen were employed in the offices of the director and of the personnel and business officer. In the division of publications 151 were engaged as follows: Management, 4; editorial section, 6; indexing section, 5; illustrations section, 26; printing section, 4; mailing lists section, 7; congressional distribution section, 16; miscellaneous distribution section, 20; addressing, duplicating, and mailing section, 63. There were 16 employees in the press service, as follows: Chief, 1; writers, 3; editor, Official Record, 1; editor, Daily Digest, 1; clerks, stenographers, and messengers, 10. In the radio service there were 6 employees: Chief, 1; writers, 3; stenographers, clerks, 2.

EXPENDITURES

The expenditures for salaries and expenses for the Office of Information were $394,893.31 during 1929. This was an increase of $24,608.77 over expenditures in 1928, which was less than the increase of $26,229 authorized by the Welch Act.

Funds available for salaries and expenses	$400,729.00
Appropriation	379,500.00
Salary limitation	338,000.00
Amount needed for Welch Act adjustments	26,229.00
Amount granted for Welch Act adjustments	21,229.00
Expenditures for salaries	360,339.49
Expenditures for general expenses	34,553.82
Total expenditures	394,893.31
Unexpended	5,835.69
Total	400,729.00

The expenditures and obligations for printing and binding, together with the number of copies of each publication and pieces of job work printed during the year are given in Table 1.

TABLE 1.—*Expenditures and obligations for printing and binding, 1929*

Item	Expended and obligated	Number of copies
Agricultural Situation	$2,696.18	126,130
Annual reports	10,041.76	44,920
Binding	21,730.42	12,149
Circulars	19,883.47	606,745
Climatological Data	1,497.99	4,000
Clip Sheet	3,405.41	286,214
Congressional documents	1,537.46	10,104
Crops and Markets	56,747.68	1,650,670
Emergency field printing	2,510.06	----------
Experiment station bulletins and reports	3,705.13	49,300
Experiment Station Record	17,710.66	136,780
Farmers' bulletins:		
New	30,630.31	1,685,832
Reprints	155,863.86	12,376,204
Lists	7,385.15	6,100,000
Forest Service recreational folders	7,728.77	402,050
Forest Worker	1,719.13	6,560
Inventory of Seeds and Plants Imported	4,145.48	16,000
Job work	176,605.80	72,138,195
Journal of Agricultural Research	5,487.57	61,938
Journal of Agricultural Research separates	18,659.56	165,111
Leaflets	7,110.17	1,288,688
Letterheads	8,445.74	4,410,700
Lists of new publications	454.00	374,800
Miscellaneous publications	21,827.95	752,553
Official Record	10,840.87	849,159
Posters	1,442.72	127,000
Service and Regulatory Announcements	9,936.10	652,131
Soil surveys	59,499.71	97,976
Statistical bulletins	7,690.31	16,551
Technical bulletins	49,159.52	520,051
Unnumbered publications and reports	22,200.07	300,808
Weather Review	8,989.72	19,159
Weather Review separates	701.22	14,800
Yearbook	56,733.41	40,000
Yearbook separates	2,492.70	112,773
Total	817,216.06	[1] 105,456,051
Appropriation		742,000.00
Overobligated and transferred to account for 1930		75,216.06

[1] Exclusive of number of copies printed under "Emergency field printing."

PUBLICATIONS

All of the department's publishing is handled by the Office of Information through its division of publications. This division plans and carries forward a publishing schedule in keeping with the educational program of the department and in accordance with funds available. While practically all the manuscripts are prepared by scientists and other workers in the bureaus, the division of publications aids in making manuscripts concise, effective, and accurate. All interbureau and department-policy matters regarding published material are responsibly handled. The division also assists the bureaus in observing the regulations of the department and of the Government Printing Office respecting publishing, and it determines the style and form of the various series of publications.

The function of the division is wholly informational. It confines itself strictly to arranging for the publication of research results and of educational and other material arising from the department's manifold activities in law enforcement, agricultural extension, crop and market reporting, pure research, etc.

The department's publishing for 1929 followed the regular program which has been evolved from 67 years' experience. It is the program which seems best adapted to the current needs of the farmers, the various agricultural-research institutions, extension groups, and the general public. Publications are classified according to the needs of different groups of readers. Scientific workers demand much more detailed and precise accounts of research than do farmers and other nontechnical readers generally. Fundamental research accounts are published in technical bulletins, statistical bulletins, and in the Journal of Agricultural Research, primarily for technicians, teachers, and students. Semipopular material is published in circulars, miscellaneous publications, and unnumbered publications. The popular publications consist mainly of farmers' bulletins, leaflets, and the Yearbook of Agriculture.

A considerable volume of the department's work requires a regular, predetermined publishing program. This work should be distinguished from the printing of bulletins on the completion of specific studies. Periodicals are published to disseminate current information. These include: Agricultural Situation, Clip Sheet, Crops and Markets, Experiment Station Record, Forest Worker, Journal of Agricultural Research, Monthly Weather Review, Official Record, Public Roads, Snow and Ice Bulletin, and Weekly Weather and Crop Bulletin.

NEED OF INCREASED FUNDS FOR PRINTING

The Department of Agriculture has grown so rapidly in recent years that the results of its work have been accomplished and classified in a much greater volume than could be printed with the funds available. The present activities of the department, with no allowance for future expansion, require an annual printing expenditure of approximately $965,000. The requirements are, roughly, as follows: Fixed charges, including job printing, blank books, letterheads, periodicals, Yearbook, annual reports, inventories, and regulatory announcements, $490,000; technical publications, $105,000; popular publications, $190,000; revisions and reprints of all classes of publications except farmers' bulletins, $35,000; soil surveys, $100,000; miscellaneous publications, Forest Service maps, and handbooks, $45,000.

This amount, of course, is greatly in excess of the appropriation for 1929 for printing and binding, and it is also in excess of the appropriation for 1930, which is $100,000 greater than that for the preceding year.

Not since 1924 has a good balance existed between the department's work as a whole and publication of the results achieved. Since that year funds for research alone have been increased by $5,000,000, and for department work in general, not including funds for Federal-aid roads, by $20,000,000, whereas printing funds up to the close of the fiscal year 1929 remained practically stationary. Average annual funds for printing in the period 1921–1930 were $744,867.58. The expenditures were $788,365.91 in 1923 and $756,546.64 in 1924. The corresponding figure for 1925 and also for 1926, 1927, and 1928 was $738,000. For 1929 it was $742,000.

SERIOUS ARREARAGE IN PUBLICATION PROGRAM

As a result of the discrepancy between printing requirements and printing funds, the department's publication program is heavily in arrears. Expressed in terms of estimated cost, the arrears at the close of

the fiscal year 1929 for different kinds of publications were as follows: Technical bulletins, circulars, and other publications giving chiefly the results of research, 272 manuscripts, $140,745; farmers' bulletins, leaflets, and other publications intended primarily for the farmers, $40,936; soil surveys (1925–1928), $420,000; Index of Animal Parasites, $30,000; Soils of the United States, $6,000; Fruit and Vegetable Disease Handbook, $50,000; World Climatological Data, $26,500; analytical index of all department publications and miscellaneous indexes, $25,000; binding, $35,780; Forest Service maps, $7,550; inventories, regulatory announcements, and miscellaneous publications, $30,544; bibliographies, $20,000. These items total $833,055.

AFFECTS WORK OF BUREAUS

The congestion in the publishing program has a detrimental effect on the work performed by the various bureaus and offices. For example, the task of surveying and classifying all the soils of the United States has been going forward steadily, under considerable pressure from many quarters to speed up the work. The soil surveys are necessary as fundamental scientific data on which to base future work in land classification and utilization. They are used in the development of local agricultural programs by experiment stations and county agents. Lack of funds to publish the results makes field work on soil surveys less effective than it might be. At the close of the fiscal year 1929 the surveys for 1925 were being printed. The Bureau of Chemistry and Soils had completed or partially completed 210 surveys, which would cost $420,000 to publish.

The situation with respect to technical bulletins shows how bureau work is adversely affected by the printing situation. On June 30, 1929, 44 technical manuscripts were held in abeyance by the Bureau of Agricultural Economics, 24 by Biological Survey, 20 by Chemistry and Soils, 76 by Entomology, and 58 by five other bureaus. Research now in progress is being impeded because these manuscripts are not readily available to all workers who should have them. It is not only necessary to make an effort to publish the accumulated technical manuscripts, but the program should be broadened to keep up with new lines of endeavor, such as Weather Bureau investigations under the air commerce act; cooperative marketing, cotton-staple estimates, truck-crop estimates, corn-borer research, tobacco stocks and standards act in the Bureau of Agricultural Economics; soil-erosion studies in the Bureau of Chemistry and Soils; biological survey investigations under the new project for the acquisition of lands for migratory-bird refuges; Mediterranean fruit-fly investigations by the Bureau of Entomology; increased work in forest protection, management, economics, and taxation under the Clarke-McNary and McSweeney-McNary laws; gipsy moth, Japanese and Asiatic beetle work by the Plant Quarantine and Control Administration; phony-peach and sugar-beet curly-top investigations by the Bureau of Plant Industry. Examples could also be given of how the failure to publish popular bulletins, periodicals, and statistical bulletins, adversely affects the work of the bureaus. From the farmers' viewpoint, a delay in printing means that the discrepancy between the knowledge possessed by this department and that possessed by them is greater than necessary. Much priceless unpublished information is in the possession of individual department workers. Farmers who need this information can get it only by contact with these individuals through correspondence or otherwise. This is time-consuming and wasteful. All pertinent information should be made public property and easily available.

The figures given above, based upon a detailed survey made during February, March, and April, 1929, show that available funds are not sufficient to keep the department's publishing abreast of its progress in research or to do all the educational work that could usefully be done by means of official publications. Much of the responsibility falling upon the division of publications at present, therefore, consists in the establishment of a rational priority in the material awaiting publication and in seeing that different phases of the department's work do not suffer disproportionately from the present situation.

GROWING DEMAND FOR PUBLICATIONS

Meantime, the demand for information, particularly on production technic and on the economic phases of agri-

culture, grows rapidly. The educational activities of the farm organizations, the work of our enlarged extension forces, discussions on agriculture by hundreds of public leaders, public attention focused on farm problems by the press and radio, and many other agencies have so greatly increased the demand for accurate information on agriculture that the offices of the department have been taxed to meet the situation. Letter writing and the preparation of special papers and manuscripts to meet specific requests are not economy when well-planned publications would satisfy this demand.

DISTRIBUTION OF PUBLICATIONS

Despite the handicaps mentioned, a great deal of effective educational work was done during 1929 by means of the department's publications. All told, the department in the fiscal year 1929 distributed free over 25,000,000 bulletins, periodicals, and other publications. In addition, the Superintendent of Documents sold more than 1,000,000 copies at prices barely covering the cost of printing. The distribution of farmers' bulletins totaled more than 11,250,000 copies. Much material, both technical and popular, was issued in mimeographed and multigraphed form, amounting during the year to nearly 53,000,000 pages. In the popular publications technical instruction for farmers held first place. Publications about diet and household subjects were in strong demand. The greatest increase in demand was for publications dealing with economic phases of agriculture, and it is in this field more than in any other that we lack the popular type of publication. There are difficulties, it is true, in the preparation of simply written, accurate bulletins on agricultural economic problems, but certainly this need must be adequately met by the department.

By law, Members of Congress are entitled to distribute publications prepared especially for the farmers, particularly the farmers' bulletins, leaflets, and the Yearbook of Agriculture.

CONGRESSIONAL DISTRIBUTION

Members of Congress during 1929 distributed through the Office of Information 7,156,037 farmers' bulletins. They also distributed 101,062 copies of publications other than farmers' bulletins. Of these, 57,604 were leaflets, 15,504 were radio cookbooks, and 27,954 were miscellaneous publications. If to these are added the 5,519,930 copies of lists of farmers' bulletins used by Members of Congress, it is seen that the congressional distribution amounted to about one-half of the total distribution.

YEARBOOK OF AGRICULTURE

Wide distribution was obtained through Senators and Congressmen for the department's Yearbook, which has a circulation annually of about 400,000 copies. This volume contains the annual report of the Secretary of Agriculture to the President and numerous popular articles on recent progress in agricultural science and practice. It is intended primarily for the farmer. Each article it contains is written by a qualified specialist and gives the latest results of research and regulatory or service work done in the department. The Yearbook for 1928 was the third in a series prepared under the editorship of the Director of Information and designed to cover authoritatively, though not in great detail, all the more important recent developments affecting the production and consumption of agricultural goods. This series of Yearbooks has proved exceedingly popular with farmers and also of wide general interest. A similar volume for the current year is in preparation.

ILLUSTRATIONS

Nearly 165,000 prints, negatives, slides, enlargements, etc., were produced by the photographic unit for use in the illustration of bulletins, press stories, exhibits, for sale, and for other purposes. The drafting unit produced 2,308 drawings, graphs, cover pages, etc.

DECREASE IN DISTRIBUTION

Although the Office of Information distributed during the fiscal year 1929 about 8,500,000 fewer copies of publications than during the previous year, the bulk of the decrease was in the lists of farmers' bulletins, which showed a decrease of nearly 6,000,000 copies. Because of lack of printing funds, the supply of more than 100

farmers' bulletins became entirely exhausted in the early part of the fiscal year 1929 and could not be replenished for months. In consequence, the number of these bulletins distributed showed a decrease, while the demand increased. But the expenditures for farmers' bulletins were larger than for any recent year. There was also a small decrease in the distribution of other publications, due to the policy of gradually restricting the free distribution of the more technical publications in order that funds might be available for the printing of bulletins on a greater variety of subjects.

The balance of publications on hand was less on June 30 this year than on June 30 last year. Approximately 10,000,000 copies were held. Of these, more than 6,000,000 copies were farmers' bulletins.

ECONOMIES

Effort to effect economy in publications was continued. The usual careful editorial and printing supervision was maintained to insure that bulletins were printed in small type, with economical units in pagination, low quality of paper, and with reductions in the number and size of illustrations. Further economies could be effected in many cases by reducing the number of illustrations. In a new octavo publication which is plated, a half-tone cut adds approximately $7 to the cost of the page and a line cut about $4. The discontinuance of the publication of the field report, comprising all the soil survey reports issued during the year, and officially known as the "Annual Report of Field Operations, Bureau of Soils," became effective by authority of the Joint Committee on Printing in August, 1928. The elimination of the bound volume results in an annual saving of $5,500, including the elimination of the making of plates for printing, which were heretofore necessary. Efforts to prevent the extravagant changing of proofs by authors resulted in a saving of $2,136.85, as compared with the expenditure for that item the previous year. The demand for "rush work" involving a 50 per cent additional charge has been discouraged, and it is becoming more and more the policy to refuse to request "rush work" from the Government Printing Office. Bureaus aid greatly in reducing this expense by placing orders in ample time to handle them in the regular way. In cooperation with the bureaus, the size of editions of many bulletins was reduced by a careful use of the mailing lists maintained by the Office of Information. The practice of sending announcements of new publications, particularly those of a technical nature, instead of sending publications direct, was followed with satisfactory results. During the year the details were worked out, and on July 1, 1929, leaflets were made available to Congress for distribution. The unit cost of a leaflet is only half that of a farmers' bulletin. The leaflet is brief, attractive, and pertinent. By its use information can be distributed widely at relatively small cost. If leaflets become a sufficiently large percentage of the total congressional distribution, a real saving will be effected.

ALLOTMENT OF FUNDS

An allotment system for the use of printing funds was adopted at the beginning of the fiscal year 1929. To each bureau a certain sum was allotted, and by this plan the bureaus naturally assumed greater responsibility in the selection of material for publication, and they readily cooperated in the plan. Estimates of the expenses incurred were furnished to them monthly by this office. Manuscripts were sent to the printer in a more even flow. As a general rule, one-twelfth of each bureau's allotment was expended each month. The system worked toward getting maximum results from available funds. It also resulted in the transfer of many accumulated manuscripts from the editorial office of the division of publications to the editorial offices of the bureaus, so that the number of manuscripts held by the division of publications was less on June 30, 1929, than on the same date of the preceding year. The number of manuscripts held in abeyance by the bureaus increased tremendously.

INDEXES

The Office of Information prepared and printed a number of special publications and indexes. Indexes prepared were as follows: Index to volume 7 of the Official Record; index to volumes 36 and 37 of the Journal of Agricultural Research; index to 1928 Yearbook. The following title pages

and tables of contents were issued: Department Bulletins 1401–1425, 1426–1450, and 1451–1475; Technical Bulletins 1–25, 26–50, and 51–75; Farmers' Bulletins 1501–1525 and 1526–1550. The index to Farmers' Bulletins 1001–1500 was compiled and sent to the printer. Progress was made on the index for all department publications from 1901 to 1925, made up of nearly 400,000 cards.

EDITORIAL PREPARATION OF MANUSCRIPTS

Much improvement could still be effected in the editorial preparation of manuscripts submitted to this office for publication. Too many inessential details are included, particularly in tables and reviews of literature. Farmers' bulletins could be improved by omitting or condensing excessive academic material and giving additional emphasis to the practical side of the information contained. The new leaflet series is proving very popular because of the brevity, conciseness, usefulness, and attractiveness of the material presented.

A review of the department's publishing would not be complete without a reference to publications printed by the States under the joint authorship of State and Federal workers. These publications are more numerous than is generally known and are valuable contributions to the solution of the more localized agricultural problems. Of the total of about 7,000 projects of research in the different branches of agriculture now active at the State agricultural experiment stations, between 12 and 13 per cent are conducted cooperatively with the bureaus of the department.

EXTENSION SURVEY

During 1929 M. C. Wilson of the Extension Service completed a study of the relative effectiveness of various extension methods. This survey showed that the printed word is by far the cheapest and least time-consuming method of inducing farmers to adopt improved practices. The survey was conducted in 17 States. In computing the ratio of practices adopted by farmers to the cost of the various methods, the following data were obtained:

Method	Practices adopted per unit of cost
News service	2.79
Circular letters	1.83
General meetings	1.72
Office calls	1.56
Bulletins	1.40
Farm or home visits	1.13
Leader training and method demonstrations	1.04
Result demonstrations	.47
Correspondence	.45
Telephone calls	.44
Extension schools	.34
Exhibits	.18

It was brought out that 6.2 per cent of the annual extension expenditures is chargeable to bulletins and circulars distributed to farmers and farm home makers. The percentage of improved practices credited to the reading of bulletins and circulars was 8.6 per cent. If the costs of news stories, bulletins, circular letters, and study courses are grouped together, the printed word appears as our cheapest teaching method. Money spent on bulletins yields a return 40 per cent higher than the average return from all extension methods.

OTHER SURVEYS

A national association, with headquarters in Washington, D. C., conducted a farm survey during the fiscal year 1929, which showed that practically all the farmers interviewed had read farmers' bulletins and that 53 per cent of them a bulletin on a certain phase of agriculture. Eighty-six per cent of those who had done so had put the information thus acquired to practical use. An extension survey in Wisconsin showed that while farmers secure more information from farm journals and newspapers, with their vastly greater circulation, than they do from bulletins, they use bulletins extensively. These data are valuable as a general guide in planning agricultural-education programs. They suggest the necessity of expansion in the department's publishing work.

STATISTICAL REPORTS

The following tables and summaries record the work performed by the division of publications during 1929.

TABLE 2.—*New manuscripts, (including revisions of publications requiring new titles and numbers) for department publications handled July 1, 1928, to June 30, 1929*

Item	Manuscripts on hand June 30, 1928	Received	Disapproved	Sent to Government Printing Office	Withdrawn	On hand June 30, 1929
Agricultural Situation		12		12		
Annual reports		15		15		
Circulars:						
New		60	2	53		5
Reprints and revisions		8		8		
Climatological Data		9		9		
Clip Sheet		52		52		
Crops and Markets		12		12		
Department bulletins:						
New	1	4		5		
Reprints and revisions		34		34		
Department circulars:						
New	16			16		
Reprints and revisions		7		7		
Experiment station bulletins and reports		12		12		
Experiment Station Record		16		16		
Farmers' bulletins:						
New	19	37		46		10
Reprints and revisions		555		555		
Farmers' bulletin lists		9		9		
Forest Service recreational folders		21		21		
Forest Worker		6		6		
Indexes		15		15		
Inventory of Seeds and Plants Imported		7		7		
Journal of Agricultural Research		30		30		
Journal of Agricultural Research separates	26	169	19	115	3	58
Leaflets:						
New		27	2	22		3
Reprints and revisions		29		29		
List of New Publications		12		12		
Miscellaneous circulars:						
New		3		3		
Reprints and revisions		7		7		
Miscellaneous publications:						
New	6	27	1	32		
Reprints and revisions		6		6		
Monthly Weather Review		12		12		
Monthly Weather Review separates		38		38		
North American Fauna		1		1		
Official Record		52		52		
Posters		5		5		
Public Roads		12		12		
Service and Regulatory Announcements		90		90		
Snow and Ice Bulletin		18		18		
Soil surveys (advance sheets)		38		38		
Soil surveys (field operations)		1		1		
Statistical bulletins:						
New		3		3		
Reprints and revisions		1		1		
Technical bulletins:						
New	30	62	3	72		17
Reprints and revisions		13		13		
Unnumbered publications and reports:						
New		52		51		1
Reprints and revisions		1		1		
Weekly Weather and Crop Bulletin		52		52		
Yearbook		1		1		
Yearbook separates	37	32		69		
Total	135	1,685	27	1,696	3	94

TABLE 3.—*Summary of publications received and distributed by the Department of Agriculture from July 1, 1928, to June 30, 1929*

Item	On hand July 1, 1928	New	Reprints	Received	Distributed	On hand June 30, 1929
Agricultural Situation		127,500		127,500	127,500	
Annual reports	20,961	43,300	1,000	44,300	35,633	29,628
Atlas of American Agriculture	2,964	5,000		5,000	2,186	5,778
Circulars	184,644	252,094	20,500	272,594	281,373	175,865
Climatological Data		4,124		4,124	4,124	
Climatological Data (Section Summary).						
Clip Sheet		280,000		280,000	280,000	
Crops and Markets		1,649,000		1,649,000	1,649,000	
Department bulletins	552,397	5,000	152,025	157,025	223,497	485,925
Department circulars	749,928		48,500	48,500	439,869	358,559
Experiment station bulletins and reports	17,705	52,000		52,000	59,060	10,645
Experiment Station Record	24,222	115,200		115,200	129,283	10,139
Farmers' bulletins	6,073,673	990,942	10,317,538	11,308,480	11,296,467	6,085,686
Farmers' bulletin lists	711,830	4,808,100		4,808,100	5,519,930	
Forest Service recreational folders		209,000		209,000	202,885	6,115
Forest Worker		6,500		6,500	6,500	
Indexes	17,250	55,250		55,250	51,358	21,142
Inventories of Seeds and Plants Imported	3,833	10,000		10,000	8,169	5,664
Journal of Agricultural Research	14,440	70,000		70,000	62,478	21,962
Journal of Agricultural Research separates	184,166	155,400	1,800	157,200	119,459	221,907
Leaflets	426,982	469,000	535,000	1,004,000	770,225	660,757
List of New Publications		317,700		317,700	317,700	
Miscellaneous circulars	457,553	34,000	155,300	189,300	305,233	341,620
Miscellaneous publications	123,905	474,972	155,000	629,972	566,253	187,624
Monthly Weather Review		18,800		18,800	18,800	
Monthly Weather Review separates		600		600	600	
North American Fauna	3,081				85	2,996
Official Record		850,400		850,400	850,400	
Posters	423,667	24,000	16,000	40,000	95,217	368,450
Public Roads	3,685	52,600		52,600	49,273	7,012
Service and Regulatory Announcements	486,862	575,300	29,500	604,800	599,828	491,834
Snow and Ice Bulletins		24,000		24,000	24,000	
Soil surveys (advance sheets)	54,575	71,000	22,000	93,000	46,704	100,871
Soil surveys (field operations)		1,000		1,000	1,000	
Statistical bulletins	34,892	21,000	2,000	23,000	19,247	38,645
Technical bulletins	154,168	191,500	25,500	217,000	205,931	165,237
Unnumbered publications and reports	470,060	399,550	80,000	479,550	404,982	544,628
Weekly Weather and Crop Bulletin		241,800		241,800	241,800	
Yearbook	17,068	20,000		20,000	19,109	17,959
Yearbook separates	105,011	63,650	21,500	85,150	68,551	121,610
Total	11,319,522	12,689,282	11,583,163	24,272,445	25,103,709	10,488,258

SEGREGATION SHOWING DISTRIBUTION OF FARMERS' BULLETINS FROM JULY 1, 1928, TO JUNE 30, 1929

Publications distributed by members of Congress	7,156,037
Initial distribution on lists	72,000
Orders from bureaus	1,173,178
Extension Service distribution	827,628
Miscellaneous	2,067,624
Total	11,296,467

CONGRESSIONAL DISTRIBUTION OF BULLETINS

Farmers' bulletins	7,156,037
Cookbooks, leaflets, and miscellaneous	101,062
Farmers' bulletin lists	5,519,930
Total	12,777,029

OTHER DISTRIBUTION DATA

Communications requesting information	877,064
Communications referred to bureaus	17,440
Communications referred to other departments	6,040
Orders on Superintendent of Documents	527,136
Congressional letters received	18,926
Postal cards addressed	27,184
Franks addressed	35,974
Letters written	1,794
Index cards written	2,754
Addresses written for bureaus	8,112
Form letters addressed	2,680
Letters containing remittances received	11,136
Amount of remittances	$3,437.51
Visitors requesting publications	3,302
Publications given to visitors	27,173
Telephone calls	20,599

OTHER DISTRIBUTION DATA—Contd.

Foreign requests	4,860
Publications sent to foreign addresses	283,059
Cost of postage for foreign mail	$4,168.58
Stencils maintained for mailing purposes	643,544

DRAFTING WORK

Drawings	125
Graphs and charts	443
Maps	92
Lettering	520
Retouching	237
Layouts	402
Air brush	87
Cover pages	84
Posters	14
Placards	114
Miscellaneous	175
Engrossing	15
Total	2,308

PHOTOGRAPHIC WORK

Photographic prints	102,889
Negatives	13,980
Negatives developed	2,172
Rotaprint plates	956
Lantern slides	9,602
Lantern slides, bound	6,776
Lantern slides, colored	745
Solar bromide enlargements	1,864
Prints dry mounted	3,611
Transparencies	59
Transparencies, colored	21
Photostats	15,857
Bromide enlargements	3,117
Bromide enlargements, mounted	2,262
Bromide enlargements, colored	276
Total	164,187
Prints sold to public	2,275
Lantern slides sold	68
Bromides sold	74
Reimbursement for above	$456.97
Reimbursement from bureaus for material	$9,420.91

MIMEOGRAPHED AND MULTIGRAPHED WORK

Stencils cut	15,581
Segments of type for multigraphing	8,352
Mimeographed pages	30,008,968
Multigraphed pages	22,699,289
Total pages	52,708,257

APPROVED MANUSCRIPTS PREPARED BY DEPARTMENT EMPLOYEES PUBLISHED IN OUTSIDE MAGAZINES

Bureau	Number of manuscripts
Agricultural Economics	84
Animal Industry	127
Biological Survey	185
Chemistry and Soils	190
Dairy Industry	23
Entomology	128
Experiment Stations, Office of	3
Food, Drug, and Insecticide Administration	73
Forest Service	256
Home Economics	26
Information, Office of	1
Plant Industry	209
Public Roads	112
Total	1,417

PRESS RELATIONSHIPS

The appetite of the press for information on the work of the department during the past year has been in line with the increased public attention focused on the agricultural problem and the growing interest of the public in the results of scientific research and in economic information. The demand for an increased flow of articles and photographs has come particularly from newspapers, syndicates, press associations, and special writers.

The press service has not been able to meet all demands. In some cases it has been necessary to send out raw material to be worked over by editors. Four writers—one of whom devotes only part time to writing—can not possibly do justice to the vast amount of data in the department which should be made available to all classes of newspapers and magazines. Accuracy is absolutely essential, and the best guaranty of that quality is sufficient personnel in the press service to meet the growing demands of the press.

ASSOCIATED PRESS FEATURES

One of the best examples of the importance given to agricultural information by the newspapers is to be found in the farm-news and science pages issued by the feature service of the Associated Press. The press service has supplied a large proportion of the farm-news material since the Associated Press established its feature service. That it has been pertinent is shown by the fact that during the past year the Associated Press began issuing two of these pages each week instead of one, giving the morning papers and the evening papers each a separate page. In addition to supplying articles, photographs, and fillers for these pages, for nearly six months the Associated Press has also been given a weekly feature called "Flowers, Shrubs, and Trees," prepared by a group of specialists in the Bureau of Plant Industry. This feature has proved a success, and plans are now being made to place other features with syndicates serving large numbers of newspapers.

OTHER SYNDICATES

The phase of press-service work deserving most attention, in view of promised returns in space and circulation, is the contacts established with press associations and syndicates,

which reach all corners of the country and all classes. At present material is being regularly supplied to the Associated Press (news and feature), the Newspaper Enterprise Association, Western Newspaper Union, Foreign Language Information Service, Congressional Press, Capital News Bulletin, and many others, including picture services. Only one of these services, the Foreign Language Information Service, makes a report to the press service on the use made of material. This service used 76 department articles during the year, and, on an average, each article was used by more than 23 publications.

The Associated Press feature service has probably given the widest distribution to department articles during the year, using at least six articles each week for the morning and evening papers, counting a half column of filler as a single article. The Newspaper Enterprise Association, which serves several hundred papers, uses some articles each week, always several short items, and often an illustrated feature. The Western Newspaper Union, which supplies the "boiler plate" for hundreds of country weeklies, uses much material in its agricultural, horticultural, livestock, dairy, and household pages. This syndicate depends on the press service for its entire supply of household articles and illustrations. When more attention can be given to photographs, it is certain that much more agricultural information will be used by this service and others.

It must be said in favor of the newspaper syndicates that their entrance into the farm field is a fair guaranty of accuracy for agricultural information. The syndicates secure their material from reliable sources, have it verified, and then give its wide distribution.

NEWS PHOTOGRAPHS

Photographs have long been of great importance in interesting readers in agricultural information; in the last few years the demand for them has grown materially. This demand has been met to some extent through the part-time use of one photographer who has been sent out to supply rush requests from all quarters when no suitable pictures were on hand. The wide use made of these photographs amply justifies the work.

During the year, because of the resignation of a member of the staff especially qualified for the work, it was necessary to discontinue the preparation of the simple charts and graphs that were supplied to one of the press associations. Only a casual study of newspapers, farm journals, and trade publications is sufficient to show that the press service might very well develop the use of this sort of informational material and make it a permanent service. It is the best means of interpreting economic data for the general public and is often useful in clarifying other information. Under the existing pressure to supply photographs, however, it is impossible to continue the preparation of graphs with the present staff.

BUREAU PRESS PERSONNEL

Some of the bureaus are lacking in the personnel for carrying out cooperation with the press service as specified in department regulations, but there are indictations of some improvement. The Food, Drug, and Insecticide Administration during the year created the position of agricultural writer, and with the assistance of the press service selected a man to fill it. As a result a great deal more information on this branch of the department's work has appeared in the press. The Bureau of Animal Industry is taking on an additional man for the same type of work, and other bureaus are making plans to do the same. This is a most necessary development if the results of research and other work are to be given out promptly and effectively. The goal should be an information organization comparable to the organization of subject-matter specialists in the Extension Service.

1,013 REGULAR RELEASES

During the fiscal year the press service issued for general circulation or for wide circulation to farm journals and trade publications 1,013 regular mimeographed releases, 45 special articles for individual papers or magazines, 52 issues of Page, Line, and Paragraph (a widely used service to the rural press), and 52 issues of the Clip Sheet, each issue containing about 10 articles. The press service also issued, for the information of department workers, 52 issues of the Official Record, and 333 issues of the Daily Digest. Further, information material and photographs were supplied to writers and editors for a large number of articles prepared by themselves.

There are many requests for special articles, which are of course hard to supply. In addition to those already mentioned, the press service has supplied quite a regular demand for home economics articles from a number of papers of large circulation.

SURVEYS DURING 1929

Four surveys were conducted during 1929 which have a vital bearing on the work performed by all agricultural people who from time to time give information to the press. The data obtained are especially significant for the department's press service.

One significant survey conducted during 1929 by a prominent national association shows that farmers benefit materially from agricultural articles in magazines and newspapers. This survey, conducted in 35 States, finds that more than 80 per cent of all farmers read one or more farm papers, and that 29 per cent read two farm papers.

From this national survey it was also estimated that 70 per cent of the farmers in the United States take a daily newspaper and that 52 per cent take a weekly paper. Of the daily papers taken by farmers, 43 per cent have a farm page or department, and 84 per cent of the farmers interviewed reported that they are interested in the farm page. In several States practically every newspaper carries a regular farm page or department, with much of the material supplied by county agents, the State agricultural editors, and the press service of this department.

M. C. WILSON'S SURVEY

The detailed research work done by M. C. Wilson (mentioned under the report on publications) not only proves that readers pay attention to agricultural articles in the press, but that the farmers reshape their farming operations as a result of the information given. Mr. Wilson says:

> Farm people read and apparently apply what they learn through reading. Studies of representative farms in three North Central States indicate that 79 per cent of the farmers take daily papers, 50 per cent take country weeklies, 93 per cent take one or more farm papers, and 59 per cent of the farm homes subscribe to home-economics magazines.

A detailed study of this comprehensive report of the Extension Service shows that the news story is relatively the cheapest, most effective, and least time-consuming extension method used to-day.

PRESS SERVICE STUDY

The Office of Information has not been in a position to carry on extensive studies. However, during 1929, a study was undertaken by the press service to determine the comparative amounts of agricultural-education material used by the metropolitan press to-day and 10 years ago. The survey was designed to be of value to the Office of Information, to other branches of the department, to editors and publishers, and to aid in determining the forms of service which the press finds most useful in disseminating information originating in the department. It consists in identification and measurement of news and information of value or of interest to the agricultural industry as it appears in the press. The survey is classified under five principal heads: News, editorial comment, features, market news, and miscellaneous. Subheads divide these classifications, usually according to the source of the item. It covers the last seven days of June, 1929, as compared with the corresponding seven days of June, 1919.

The personal equation was eliminated by selecting the papers for survey under an arbitrary rule. The Library of Congress has approximately 200 bound files of daily newspapers available for the two years. These were arranged in order of descending circulation figures; a number of dailies published for special groups or with specialized interests were eliminated, leaving only dailies of standard size and of general circulation in their communities, 31 in all.

Measurement of 11 of the dailies of larger circulation on the list has been made. Without exception, each of these devoted more space in the last seven days of June this year than in the same days 10 years ago to agricultural items classified under "news." For the 11 papers the increase in "news" amounts to 91 per cent. Total space devoted to all agricultural items is 53 per cent greater for 1929 than for 1919. Two papers show a decline in total number of inches of space devoted to agricultural interests. In one the decrease was trifling. In the other the decrease is due to a typographical condensation of market news and tables, and this daily carried 88 per cent more under the "news" classification.

One newspaper of national reputation devoted more than five times as much space to agricultural interests in 1929 as in 1919, and if the "market news" space is excluded the total of the news, editorial, feature, and miscellaneous classification is more than twelve times as great for the second period as for the first. The news classification alone is ten times as large.

The preliminary results indicate that the metropolitan press, at least, is now in more receptive mood than it has been in regard to news and information relating to agriculture. These results suggest, at least, the advisability of making special effort in the current year to supply the press with as complete informational service as is possible.

SURVEY OF BUREAUS

The Director of Information during February and March, 1929, received from all the bureaus and offices of the department detailed reports on the usefulness of the educational work done by the press service. These reports fill more than 250 typewritten pages.

It is the press service which is most likely to be looked upon as a publicity agency rather than as a strictly educational one. Hundreds of examples could be given to show the interpretive, informational nature of the work. It was to produce these examples that the bureau survey was made. It is significant that not a single objection was registered by any of the bureaus to the type of service now performed. Bureau chiefs and many scientists who reported, praised the educational na ture of the work. A few examples are given:

(1) The successful prosecution of the program on soil erosion depends largely on educating the public to a full realization of the problem. The Bureau of Chemistry and Soils stated that the educational work of the press service had contributed enormously to awakening a national consciousness of the meaning of soil erosion, "the greatest evil relating to the physical side of land utilization in the country."

(2) From January to June, 1929, a series of special articles was prepared, interpreting the work of the Food, Drug, and Insecticide Administration. It is reported that the thorough understanding which the public received of this particular branch of the department's regulatory work is aiding greatly in carrying out the law.

(3) The recent world survey on livestock improvement shows that this country has done more educational work for better livestock than any other country in the world, a fact which is closely related to the supremacy of the United States in the quality of its breeding stock and general excellence of its commercial livestock.

(4) The Bureau of Animal Industry reported that tuberculosis eradication and tick eradication are facilitated greatly by a clear understanding on the part of the public of the importance and real purposes of the work.

(5) A report by the Bureau of Animal Industry showed that of the factors influencing farmers to take up the breeding of purebred livestock, reading was first with 36 per cent.

(6) The Forest Service submitted many concrete examples to show that educational and informational activities have proved to be indispensable to success in carrying out national-forest enterprises.

(7) The Bureau of Dairy Industry reported that information concerning the remarkable keeping quality of sweet-cream butter is resulting in its widespread use and a saving of hundreds of thousands of dollars annually. Also the work of the bureau in preventing losses due to feed and weed flavors in milk, in decreasing bottle breakage in milk plants, and in encouraging more complete utilization of the dairy by-products, skim milk and whey, is of far-reaching economic importance, and the most valuable results are accomplished by wide educational publicity.

(8) Hundreds of other examples were received on the effectiveness of publicity to further such work as: Prevention of grain-dust explosions and farm fires; nutritional investigations; sugarcane and maple-sugar work; corn-borer, tanning-materials, Japanese-beetle work; etc.

Practically all bureaus stated that more educational publicity by the department would be helpful to farmers, the department, other research and educational agencies, and the public in general. Many pointed out that news stories about research prompt readers to send in suggestions of value to the department.

CONCLUSIONS FROM SURVEYS

The surveys conducted during the year conclusively bring out these pertinent points: (1) Newspapers, farm journals, and other periodicals are widely read by farmers, who benefit materially from the accurate agricul-

tural information given therein. (2) The printed word is the cheapest and one of the most effective extension methods. (3) A greater volume of agricultural information is being used by the press than ever before.

Part of the increase just mentioned unquestionably is due to the fact that educational agencies, such as this department, the experiment stations, and the colleges, which have accurate data available, are giving them to magazines and newspapers in readable form. Newspapers and magazines would find it difficult to get an equally reliable and comprehensive report of this department's activities in any other way. It would take a good-sized reporting staff to cover the various information sources in the department, whose members are scattered in more than 40 buildings in Washington. Moreover, it would be costly and troublesome for reporters to settle the controversial points that might be involved in the preparation of many articles. Material handled through the department's press service is referred to all interested authorities before being released. A story about insecticides, for example, may require the approval of the chemists who study the poisons, the entomologists who study the insects, and the agronomists who study the plants on which the insects feed. It would be asking too much to expect newspaper reporters to go to that length in their efforts to achieve accuracy. As a matter of fact, the articles on the department's work which newspaper reporters prepare frequently lack the precision desirable.

COUNTRY-WIDE ACTIVITIES

The press service, in addition to working closely with the editorial offices of the bureaus of this department, also cooperates with the 48 agricultural colleges and the 51 experiment stations. A more definite organization, on a cooperative basis, which will correlate the work of the press service with the activities of experiment-station and agricultural-college editors is now being formed. The agricultural editors in the States prevail upon the county agents, home demonstration agents, and others to write for the press. It is estimated that there are between 2,500 and 3,000 persons regularly engaged in preparing agricultural information for the press. This number, of course, does not include the many specialists who from time to time contribute to magazines and newspapers. Specialists in the Department of Agriculture, for instance, contribute about 1,400 articles annually to various publications. A report on extension activities for 1928 shows that 2,338 county agents, 1,059 home demonstration agents, and 130 club agents contributed 371,331 articles to newspapers. They also distributed 5,608,604 bulletins.

Information specialists must be keenly alive to the knowledge which is day by day developed in the department; on the other hand, they are, because of their contacts, sensitive to the needs of farmers themselves and therefore are in a position to advise with the research specialists regarding the need for specific research which will be helpful to farmers. Since agricultural education is intended to help the farmer, it is important to know what help he would like to have.

RADIO WORK

From the chaos of conjecture and experiment in the early years of the radio industry and the broadcasting art, a pattern of certainty and the settled outline of a new business and social institution rapidly emerged during the fiscal year 1929.

All observers, within and without the radio industry, agree that the widespread use of broadcast programs by the political parties during the presidential campaign of 1928 firmly fixed the place of radio as a factor in forming public opinion. This fact has had significant influence both in the program making of the broadcasters and in the attitude of the leaders of American thought and action toward radio.

It has made the broadcasters turn their attention to ways and means of meeting their opportunity and obligation to carry on educational and information service.

The recognition of radio's service in getting facts and opinions to the listening public naturally has increased the desire of persons who have facts or opinions to set forth to obtain broadcasting time.

Another highly significant development of the year was the definite rating of commercial stations—as distinguished from stations not operated for profit or commercial "good will" purposes—in preferred positions by the complete reallocation of frequency assignment made effective November 11, 1928, by the Federal Radio Commission. In this reallocation only two

stations not operated by business interests were placed on cleared channels, and each of them must share time on the channel with another station.

Persons interested in agricultural broadcasting will pay particular attention to the status of the land-grant college stations, as to assignments of frequency and of broadcasting time. Only one land-grant college station was placed upon a cleared channel. It divides time with a commercial station on the same channel. Of the remainder all were assigned regional channels.

COMMERCIAL STATIONS PREPONDERANT

The overwhelming preponderance of commercial stations in the preferred assignments under the reallocation plainly indicates that the ability of such stations, backed by ample resources, to provide programs appealing to all interests will probably keep them in the forefront of the broadcasting picture. Their position naturally carries with it a responsibility to see that the public interest is served. They accept the obligation to supply not only commercially sponsored advertising programs of entertainment but also sustaining programs of information, education, and inspiration.

What have been the effects on the Department of Agriculture broadcasting work during the past year of the significant trends in broadcasting above mentioned? They can best be set forth by reviewing the year's developments.

CHAIN BROADCASTS

The most important of the developments was the inauguration of broadcasts through one of the great chain systems. Until this year, all the radio-service programs had been in the syndicate manuscript form, that is, they had been supplied to radio stations which agreed to cooperate by sending them on a regular schedule, and the station announcer presented them.

Last October the National Broadcasting Co. placed at the disposal of the department a network of 17 stations which carried a 15-minute broadcast from 1.15 to 1.30 p. m., eastern standard time, on Monday, Tuesday, Wednesday, Thursday, and Friday of each week. In this quarter hour members of the department staff presented during each week of the ensuing nine months timely agricultural and home-making information. During these 38 weeks 198 members of the department and 18 guest speakers sent their messages to the listening public in the 22 States served by the stations in the network. Some members of the department appeared from one to three times a month. Other speakers gave but one broadcast during the nine months. The program was designed to take to listeners (1) the most important stated reports of the department, particularly the economic reports such as the monthly price situation review, crop reports, and the outlook reports, on the day of release. For example, the cotton report in each month of its issue was summarized by W. F. Callander, chairman of the Federal Crop-Reporting Board, two hours after it was issued to the press and trade reporters at the department. The cotton grower thus had the essential facts of the report almost as quickly as the cotton trader served by the commercial wires of the telegraph companies. Besides these reports listeners were provided (2) with seasonal information on farming and home-making practices personally delivered to them by the scientists and economists who had ferreted out the facts and formulated the recommendations.

SPECIAL PROGRAMS

The department broadcasting in cooperation with the National Broadcasting Co. included besides the daily program two special broadcasts, carried on nation-wide networks, during the year. These were arranged for and supervised by the chief of the radio service, who likewise supervised the daily network broadcasts.

On January 28, 1929, a network of 38 stations extending from coast to coast transmitted the first national outlook radio broadcast. This broadcast brought to the attention of farmers in every section the survey by Federal and State agricultural economists of the domestic and foreign business and industrial situation, of the prospective demand throughout the world for each of the major farm commodities of the United States, and recommended in the light of these facts the approximate quantities of the commodities which American farmers should produce. Besides the reports by the members of the outlook committees on the eight major commodities, the broadcast included addresses by the Secretary of

Agriculture and the chairmen of the Committees on Agriculture of the Senate and of the House of Representatives, as well as music by the United States Navy Band.

On June 22, 1929, a network of 42 stations associated with the National Broadcasting Co. transmitted the second annual National 4-H Club radio night program. In June, 1928, the responses indicated that more than 100,000 4-H Club members were listening to the special broadcast. More than twice that number are estimated to have heard this year's program, which carried to the boys and girls of the Nation a message from Mrs. Herbert Hoover and from members of the National 4-H Club Camp and leaders of extension work in the United States.

MANUSCRIPT SERVICES

The manuscript programs continued to increase their influence toward the adoption of better farming and homemaking practices. Despite the reduction in number of stations by the reallocation of November, 1928, and despite the dropping from the list of cooperators of nearly a score of stations during the year because of reductions in broadcasting time or because of failure to reach the farm and home audience effectively, the stations broadcasting the Department of Agriculture manuscript services at the end of the 1929 season numbered 152, as compared with 149 in 1928. The season was marked by further development of the regionalization of programs. Although the regionalization is not yet completely satisfactory, progress was made during the year, and experience furnishes a basis for working this matter out more completely in the coming season.

REGIONALIZATION

The regionalization work was done on two daily agricultural programs—the Farm Flashes and the Farm Forum. Each provided a 10-minute service. The Farm Flashes were written to supply in an interesting form the seasonal recommendations of agricultural scientists on improved practices in farming. The Farm Forum dealt, through talks by a group of characters, with major problems of the farming industry in each of the five general program regions.

For home makers the service included the daily 10-minute feature, the Housekeepers' Chat. Aunt Sammy continued to be one of the most popular broadcasters of the Nation. Her talks through 93 stations using the Housekeepers' Chat service brought in a response of as many as 10,000 letters in one month and an average of 6,000 letters monthly during the season.

Besides these daily broadcasts, the radio service supplied to cooperating stations the following 10-minute weekly features: The Primer for Town Farmers; the 4-H Club Crier; Outdoors with the Scientist; and the Farm-Science Snapshots. A monthly review of the report on the agricultural situation also was included.

STATIONS COOPERATING

The numbers of stations broadcasting the various manuscript services and the frequency of their presentation were as follows: Housekeepers' Chat (daily), 93; Farm Flashes (daily), 97; Farm Forum (daily), 72; Primer for Town Farmers (weekly), 70; Outdoors With the Scientist (weekly), 67; Farm-Science Snapshots (weekly), 75; 4-H Club Program (weekly), 64; Agricultural-Situation Review (monthly), 80.

OTHER SERVICES

Special service was given to cooperating broadcasting stations on local agricultural problems under investigation by the department. When bulletins were issued giving information which applied mainly to a limited area served by only one or two radio stations, these stations were supplied with summaries of the contents of the bulletins for use in connection with their regular agricultural broadcasts. The department also used the service of radio stations in agricultural emergencies. For example, broadcasts by Twin Cities radio stations in September, 1928, were instrumental in getting to farmers in northern Wisconsin counties information on how to check a sudden army-worm invasion.

RESPONSES

Besides the inconclusive data available from the few surveys made, the only direct check available on radio broadcasts is the mail from listeners. Mail coming to the radio service from the various broadcasts of the past season exceeded 80,000 letters. This does not include by any means all the response to the broadcasts. Many listeners simply write to the Department of Agriculture asking questions in-

spired by the broadcasts, or requesting publications mentioned in the broadcasts. Obviously no check can be made on such response.

SURVEY NEEDED

Because of the small personnel available and the necessity for working that personnel at top speed in order to get out the programs, the radio service did not during the past year undertake any survey of the status of agricultural broadcasting. Such a survey is greatly needed in order to provide a basis for organizing information services to use this new agency of communication effectively. Such surveys as were made during the year by agencies outside of the department indicated that the farm audience is fairly well reached by the present technic of agricultural broadcasting. For example, the survey made by the National Broadcasting Co. and issued under date of January 1, 1929, included the following findings in regard to the efficiency of present general-information farm broadcasting and the listening habits and preferences of the rural radio audience:

Farm families listen more than city and town families during the daylight hours, especially between 12 noon and 2 p. m.

Preferences for most of the different types of programs are practically the same on the part of farm, town, and city families. There are significant differences, however, with respect to several types of programs—semi-classical and classical music and grand opera are preferred less by farm and small-town families than by city families, whereas religious services, crops and market reports, and children's programs are preferred more by farm families than by city families.

Nearly three-fourths of the farm families enjoy talks on agricultural subjects. The exact percentage is 72.12. Of the small-town families, 31.44 per cent, of the families in medium-sized cities, 23.45 per cent, and of the families in large cities, 10.19 per cest, likewise reported that they enjoy agricultural talks.

A smaller, more specialized study made by the Pennsylvania Department of Agriculture and published on November 1, 1928, is summarized as follows:

Of 352 farm radio owners: 231 have 5 or 6 tube sets.

315 have loud speakers.

270 make a special effort to tune in on special farm programs. **(It will be noticed** that this percentage, 76.7, tallies fairly closely with the National Broadcasting Company's survey percentage of 72.12.)

199 said they depended upon the radio market reports in buying and selling.

274 replied that radio weather reports helped them in planning their farm work.

330 were sure their families would not be satisfied without a radio.

220 believed that the radio is helping to keep young people interested in farm life.

During 1928 the Extension Service of the department made three studies of the effectiveness of extension work in influencing rural people which took radio broadcasts into account as an extension agency.

In a Rhode Island study involving 379 farms and farm homes it was found that 63 per cent were equipped with radios. No practices, however, were reported as being adopted because of information obtained by radio. In Vermilion County, Ill., 304 farm and home records were obtained. In this area 40 per cent of the homes had radios and 0.1 per cent of the improved practices reported as being adopted were credited to this agency. In a Michigan study involving Jackson County in the lower peninsula and Menominee County in the upper peninsula, 451 records were obtained. Twenty-two per cent of the farms had radios, and 2 per cent of all the practices reported as being adopted were credited to this agency.

Extension executives of the department, after analyzing fragmentary data on the cost and influence of radio, stated that while no conclusion can yet be reached, the indication is that the radio will compare well with news services in influencing the adoption of improved practices by farmers and home makers.

LAND-GRANT COLLEGE COOPERATION

The radio service enters the fiscal year 1930 equipped with a personnel more nearly adequate to supply completely regionalized manscript programs in the agricultural series and with a movement inaugurated to join with the land-grant colleges of the Nation in making this regionalization completely effective.

The chief of the radio service was invited by the radio committee of the Land-Grant College Association at the annual meeting of the association in Washington in November, 1928, to work out with the committee plans for correlating State and national agricultural broadcasts. The result of this effort is a proposal being submitted by the Directors of Extensions Work and Information of the Department of Agriculture to the 48 land-grant colleges for a cooperative service to the broadcasters of each State. This proposal, if made effective, will become an actuality in January, 1930. It contemplates the release to radio broadcasting stations, at the start, of a 10-minute daily manuscript pro-

gram jointly prepared by the United States Department of Agriculture and the State agricultural colleges. The Department of Agriculture portions of the releases will be correlated with the State college portions to give information adapted to the needs of farmers in each State on recommended agricultural practices, on scientific principles underlying them, and on the economic situation.

NEW NATION-WIDE PROGRAM

In the last month of the fiscal year plans were set up with the National Broadcasting Co. for a national farm and home hour. This period, which opened during the first week of the fiscal year 1930, represents an expansion of the 15-minute daily farm period through a network of the National Broadcasting Co. employed during 1929. The number of stations on the network has been expanded to 37. The time has been expanded from 15 minutes to 45 minutes, with entertainment and information features supplied by the National Broadcasting Co. added to the department talks to make a program designed to have the widest possible appeal. The department broadcasts five days each week, and the Saturday periods are opened to national farm organizations, to the land-grant colleges, and to the 4–H clubs.

NEW PROBLEMS

The development of farm and home radio fact broadcasting during the coming year will involve many problems of correlation. Vexing situations are likely to arise in connection with the working out of the cooperative manuscript services mentioned above. Radio knows no State boundary lines. Hence delicate matters of release of information by the States through radio stations which, although located in one State, serve an audience in several States, may conceivably arise. However, no insurmountable difficulties in this connection have arisen through the operation of the 19 land-grant college stations now broadcasting, and such as do arise through expanding farm and home broadcasting through cooperation with commercials can undoubtedly be overcome.

New technical developments foreshadowed at the beginning of the fiscal year 1930 also will have their effects upon the radio work of the department. It is probable that the "wired wireless" service will get under way for a trial at least in a midwestern city. This development holds for the future, when most farm homes will be served with electric power from central stations, a new radio outlet for agricultural information. For the present it means that the wired-wireless interests, if they attempt to compete with "space radio" broadcasters, must supply service programs for the housewife and for "town farmers." The department will be interested in both phases.

The use of phonograph-record continuities for special advertising broadcasts was taken up extensively, even by some of the most powerful stations, during the past year. Recorded continuities with the program put up either on the wax of a phonograph record or the celluloid of sound film strip promises to have even wider use in the coming season. The department should be prepared to employ this method of releasing from many stations realistic broadcasts by agricultural authorities.

Within the coming months the survey of the national committee on radio and education, appointed by Secretary Wilbur of the Department of the Interior on May 24, 1929, will undoubtedly develop valuable facts. This committee will deal not only with the elementary and high-school field and the college and university field, but with the field of informal adult education and extension—the field in which the department radio service is particularly interested. The national committee's report will be formulated in 1930. Meanwhile the radio service is making an effort to secure from representative farm listeners their stand on current developments in agricultural-extension and general-information broadcasting. Another year will see a much firmer basis for developing the use of this new public-service agency for the benefit of the farm and the home.

BUREAU INFORMATION WORK

Each bureau of the department maintains an editorial office which cooperates with the Office of Information. Work of great value is done by these offices. Some of the annual reports of the bureau chiefs contain brief accounts of the work done in 1929 by the bureau editors.

Certain information, such as the department's weather reports, its crop reports, and its daily market-news reports, depends largely for its value on

the rapidity with which it is communicated to the public. Accordingly, such reports are handled, not in this office, but directly by the bureaus immediately concerned. The Weather Bureau furnishes directly to the press bulletins concerning storms and other severe weather conditions. Its daily weather forecasts also are issued directly. Reports received by the Weather Bureau are made available to cooperating meteorologists by a bulletin broadcast twice daily from the Weather Bureau office through its radio station at Arlington, Va. All its field stations are extensive and intensive distributing agencies. They utilize maps, bulletins, circulars, and telegraph, telephone, and radio facilities. Practically every daily newspaper in the United States publishes the forecasts and special bulletins prepared at Weather Bureau stations. Increased use of radio communication during the last year enabled the bureau to reach more people more quickly with its reports. The Weather Bureau, like the other bureaus, publishes periodicals, bulletins, reports, etc., but these are handled through the Office of Information and are included in other sections of this report.

In the Bureau of Agricultural Economics more than 800 persons are mainly occupied in the distribution of current information. Three hundred are connected with the crop-reporting service and 350 with the market-news service. The others are divided among several additional informational activities. The bureau spends about $2,700,000 a year in gathering and distributing current data, aside from the results of research and special surveys. Its crop and livestock estimating service is a nation-wide organization with a staff of about 300 workers. More than 200,000 farmers, traders, bankers, and others cooperate in the crop reporting. Crop reports are issued directly to the press and to representatives of grain exchanges and commercial magazines. The Bureau of Agricultural Economics also maintains numerous special mailing lists for different types of information. Five commodity divisions in the bureau have branch offices where information is assembled and distributed over a leased-wire system, including 10,000 miles of leased wire with 49 offices and 60 telegraph operators. Outlook and price reports are issued by the bureau periodically, and much crop and market information is sent out by radio. Other phases of the bureau's information program are handled through the Office of Information. The radio was used much more extensively during the year than ever before for the distribution of the bureau's market news and economic information.

The Forest Service likewise conducts certain informational activities more or less independently of the Office of Information. It issues considerable information on forestry to trade journals and prepares numerous special articles, feature material, and other data for news and special-article writers. This material is in addition to that prepared by the Forest Service for issuance through the department's press service. The Forest Service makes educational and informational work a part of the duties of every forest officer in the field regardless of his special assignment.

SUGGESTIONS AND RECOMMENDATIONS

Developments during 1929 and in recent years show that the department's information program should be strengthened in a number of particulars.

The congestion in printing should be removed, since research results have only a fraction of their potential value if they are not published.

More speed is desirable in the editorial preparation and the publication of manuscripts. Often a year or more elapses between the completion of a study and the publication of a report thereon.

Job work, forms, letterheads, schedules, etc., require an ever-increasing proportion of the printing fund. The cost has increased from about $95,000 in 1923 to approximately $185,000 in 1929. These forms are used in the prosecution of research and regulatory work, and it usually requires 90 days to get them printed. Provision should be made to speed up job printing. Adjustments of funds should be made to prevent the delay of regular publishing by job work.

A loose-leaf binder should be secured in quantity at reasonable cost for distribution to farmers for binding farmers' bulletins. Such binders would enable farmers to keep conveniently these valuable reference sources.

C. B. Smith, Chief of the Office of Cooperative Extension Work, pointed out at a recent extension conference that the county agent could well afford to triple extension work in agricul-

tural economics. More brief, well-prepared leaflets on economic subjects would help in this work.

The voluminous correspondence carried on by administrative officials and scientists requires a great deal of time. It would be cheaper to have bulletins available to answer all stock inquiries. It would seem advisable to relieve research workers of a great deal of the routine correspondence which they must handle at present.

There are two distinct functions of practically equal importance: Putting into published form all the knowledge of the department, and giving wide distribution to the published material. We should not be compelled to reduce efforts toward the proper accomplishment of the latter, in order to have funds for the former. Both functions should be handled adequately.

In 1928 the Superintendent of Documents sold about 1,000,000 copies of our publications. This sales quota will increase rapidly just as soon as an easy means is devised for farmers to make their purchases. At present stamps are not acceptable, and money orders are troublesome and expensive for the farmers. A special stamp or card, good only for the purchase of documents, would solve this problem. Such a procedure would have to be worked out with the Post Office Department.

The press service should have several additional expert writers to interpret agriculture. The present staff is wholly inadequate to cover this vast department, scattered throughout 40 buildings. These men should associate constantly with the people of the department, in Washington and in the field, and give to the public readable, interpretative articles on the more vital agricultural subjects. This move would be wholly justified from the viewpoint of cost, as definitely proved by Mr. Wilson's study of extension methods.

Press contact men should be established in all the bureaus. This is provided for in the department regulations, and some progress has been made in that direction. Bureau editors are kept busy mainly with editing work. The newspaper and magazine side suffers proportionately.

Contribution of special articles by department specialists to scientific journals, farm journals, and other periodicals should be increased, and provision should be made for the purchase by the department of reprints which are deemed essential in the prosecution of the department's work.

Equipment should be provided so that department specialists who broadcast by radio may have an opportunity to practice their addresses before delivery. Speakers are often taken to the uptown studios for this purpose, but this requires much time.

Additional broadcasting chains are requesting special farm programs, but the department's radio service is not equipped to furnish them. It would be highly advantageous if all such requests could be filled.

Some of the agricultural colleges have very effective information programs. It would be worth while to bring three or four of the best leaders in this field to Washington to study our whole information set-up, more especially our relations with the Extension Service, in order that we may make our work more valuable to the county agents, home demonstration agents, cooperators in demonstration work, cooperative marketing associations, and, of course, the rural population in general.

Many of the positions in the Office of Information are classified too low in view of the technical training and experience required, the difficulties and responsibilities of the positions, and the allocation to higher grades of other employees in Government service positions with lower prerequisites. Qualified editors who have adequate training and experience should be classified in the professional and scientific grades on a par with scientists of comparable background. The experience of this office and of the bureaus has been that it is absolutely necessary to offer a higher compensation than is now possible if we are to hold or to attract highly qualified editors and information specialists to the Department of Agriculture.

U. S. GOVERNMENT PRINTING OFFICE: 1929

For Release to Morning Papers of December 13, 1929

LIBRARY OF THE
OFFICE OF EXPERIMENT STATIONS
DEC 14 1929
EXPERIMENT STATION FILE

REPORT OF THE LIBRARIAN

UNITED STATES DEPARTMENT OF AGRICULTURE,
OFFICE OF THE LIBRARIAN,
Washington, D. C., August 28, 1929.

SIR: I have the honor to submit herewith the report of the library for the fiscal year ended June 30, 1929.

Respectfully,

CLARIBEL R. BARNETT, *Librarian.*

Hon. ARTHUR W. HYDE,
Secretary of Agriculture.

The tables compiled by the heads of the various divisions of the library, which appear at the end of this report, give a detailed synopsis of the routine work of the library in so far as this can be expressed in statistical terms. They will be only briefly summarized here. As a whole, they show a gradual, consistent growth of the library, though the rate of growth in some directions has not been quite equal to that of the previous year.

ACCESSIONS

On July 1, 1929, the library contained, according to the accession stamp, 211,127 volumes. The number of books, pamphlets, and maps added during the year was 14,354, which is 1,451 less than the number added the previous year, principally because fewer volumes were received from the bindery.

CATALOGUING AND CLASSIFICATION

The amount of material catalogued showed also a slight decrease as compared with the amount catalogued the previous year, partly because of changes in staff in the catalogue division and partly because more time of the cataloguers was spent in the reclassification of certain classes which were much in need of subdivision. All the books on vegetables were reclassified in accordance with a scheme of classification drawn up by Marjorie F. Warner, of the Bureau of Plant Industry library. Although the number of volumes catalogued during the year was smaller, the number of cards added to the catalogue showed an increase. The Library of Congress is now practically up to date in the printing of the "Agr." series. The number of cards added to the various catalogues and indexes maintained by the bureau and office libraries also showed an increase. Detailed statistics in regard to the cataloguing are given in Tables 2 to 5.

PERIODICALS

The number of different periodicals received by purchase, gift, and exchange was 3,936, as compared with 3,683 in 1928. The number received by gift was 2,742. Of a number of the periodicals it was necessary to purchase additional copies, and extra copies of many of the gift periodicals were also received. The total number received by purchase, gift, and exchange, including the duplicates, was 4,315, an increase of 195 over the number in 1928. The total cost of the subscriptions for periodicals was $9,059.06, an item of expenditure which is steadily increasing from year to year.

No separate record is kept in the periodical division of the number of continuations received, but the records of the catalogue division show that 6,631 continuations were catalogued, and it is probable that five-sixths of the number were current issues. The serials received by the library, including periodicals and continuations, are a most important part of its collections and come from all parts of the world. More detailed statistics regarding the periodicals received are given in Table 6.

BINDING

The binding statistics are given in Table 7. These show that the number of books and periodicals sent to the Government Printing Office for permanent binding was 2,193, which is 287 less than were sent the previous year, owing to the decrease in funds available for binding. There was also a decrease in the number of books and periodicals placed in temporary binders, due to lack of funds from which to obtain binders. As explained in the report for last year, this decrease in the library binding is serious. If volumes are not bound they are inconvenient to use, and, furthermore, the danger of loss and injury is greatly increased. In order to make up for the arrears in the binding for the past few years, the appropriation for this purpose needs to be doubled.

USE OF THE LIBRARY

Detailed statistics of the use of the library, in so far as statistics are available, are given in Tables 8, 9, 10, and 11. They indicate only approximately the use of the library, as exact figures regarding the circulation can not be kept under existing conditions in the main library or in the Bureau of Agricultural Economics library. During the past fiscal year, however, the Office of Experiment Stations library, which has a large circulation in connection with the Experiment Station Record, was able to begin in September a record of its book and periodical circulation. This showed a circulation of 53,502 in the 10 months. With this sum added to the exact figures kept by the other libraries of the departments, the recorded figures of circulation this past year are a nearer approximation to the actual use. For the library as a whole they show a recorded circulation of 59,523 books and 214,980 periodicals. If to these exact figures are added the approximate figures of the circulation of current periodicals in the main library obtained by an actual count for two months, and the approximate figures of the Bureau of Agricultural Economics library based on a count three years ago of the different periodicals and dailies circulated and the offices to which they were circulated, it is believed that the total circulation would be over 450,000.

Interlibrary loans totaled 2,578. They were made to every State with two exceptions, the largest number being sent to New York State. Interlibrary loans totaling 4,724 were granted to this library by 26 libraries in Washington. Interlibrary loans from libraries outside of Washington, totaling 41, were granted by 22 different libraries, from Harvard University on the East to the University of California on the West. To all these libraries the department is greatly indebted for the help received, and particularly to our great national collection, the Library of Congress, and to the Surgeon General's Office.

LEGISLATIVE WORK

As there is much legislation each year which affects the work of the department, particularly the Bureau of Agricultural Economics and the Bureau of Public Roads, it is necessary for the libraries of these bureaus to keep careful records of new bills introduced pertaining to their work, the hearings on these bills, etc. This work requires a large amount of time as willl be apparent from the fact that 186 bills were introduced in the Seventieth Congress of interest to the Bureau of Agricultural Economics and 193 in the Seventy-first Congress. In the Bureau of Public Roads, 1,781 bills were followed during the entire Seventieth Congress, of which 670 were bridge bills, and in the Seventy-first Congress 470 bills were followed.

BIBLIOGRAPHICAL WORK

Two additions were made during the year to the mimeographed series of Bibliographical Contributions of the library, namely, No. 18 entitled "Agricultural and Home Economics Extension in the United States; a Selected List of References," prepared in the Office of Experiment Stations library by Cora L. Feldkamp, librarian, and No. 19 entitled "Cattle, Sheep, and Goat Production in the Range Country; a Selected List of Publications Issued by the United States Department of Agriculture and the Agricultural Colleges, Experiment Stations, and Departments of Agriculture of the Seventeen Range States," compiled by Emma B. Hawks, associate librarian of the department, in collaboration with Earl W. McComas, associate animal husbandman, Bureau of Animal Industry.

In the Bureau of Agricultural Economics library two additions were made to the mimeographed numbered series, Agricultural Economics Bibliography, and a revision of a previous number, as follows:

No. 26. Labor requirements of farm products in the United States; a list of references to material published since 1922. Compiled by Louise O. Bercaw. 62 p.
No. 27. Agricultural relief; a selected and annotated bibliography. Compiled by Esther M. Colvin. 53 p.
No. 1. Agricultural economics; a selected list of refences. Compiled by Mary G. Lacy. Revised February, 1929. 18 p.

Two other bibliographies were mimeographed but not issued in the numbered series. They were:

Agricultural relief; bills introduced in the 70th Congress, 2d session. Compiled by Emily L. Day. 4 p.
The meat industry in the United States; a selected list of references on the economic aspects of the industry, including meat packing, published since 1918. Compiled by Minna Gill and Lillian Crans. 24 p.

Thirty-eight reference lists were prepared and are available in type-written form. The more important of these are the following:

Exchanges; a selected list of references on exchanges in the United States handling agricultural commodities, with particular reference to future trading. Compiled by Louise O. Bercaw. 18 p.
A beginning of a bibliography on agricultural credit. Compiled by Katharine Jacobs. 10 p.
Danish agriculture; a partial list of references to publications issued since 1914. Compiled by Louise O. Bercaw and Esther M. Colvin. 11 p.
History of tobacco; a partial list of references. Compiled by Louise O. Bercaw. 11 p.
Recent changes in local banking practice; a selected list of references. Compiled by Louise O. Bercaw. 18 p.
List of foreign and domestic periodicals read each month in the library of the Bureau of Agricultural Economics in connection with the preparation of agricultural economics literature. 11 p.
Commercial canning of fruits and vegetables, 1924–June, 1929. Compiled by Esther M. Colvin. 13 p.

The library also continued its cooperation with Rural America, organ of the American Country Life Association, in furnishing regularly to that journal lists of recent material relating to the literature of rural life. The monthly publication of the library entitled "Agricultural Economics Literature" was issued throughout the year except in July and August.

In the Bureau of Dairy Industry library a revision of Bibliographical Contribution No. 6 entitled "Partial List of Publications on Dairying Issued in the United States, 1900 to June, 1923," is well under way. The revision will include all the material from the organization of the stations in 1888 up to and including 1928. It will also include all the publications on dairying issued by the department from its organization up to 1928. The revision therefore, besides bringing the material up to date, will be enlarged in scope. Two reference lists were issued by the library during the year, namely, Dairy Library List No. 1 entitled "List of Publications of the Bureau of Dairy Industry from July 1, 1924, to December 31, 1928," and Dairy Library List No. 2 entitled "Publications of the Department of Agriculture Relative to Dairying Available for Free Distribution."

In the Bureau of Entomology library the check list of publications of the United States Department of Agriculture relating to entomology was completed and is now being mimeographed. The fourth Index to the Literature of American Economic Entomology is now in its fifth and last year of compilation. A catalogue of the books, bulletins, and pamphlets on bees contained in the library, which was prepared by an assistant of the Bureau of Entomology and an assistant of the main library, in cooperation with the bee culture laboratory, is nearly completed, and it is hoped that it will be mimeographed within the next few months.

In the Office of Experiment Stations library the fourth biennial supplement to the United States Department of Agriculture Bulletin 1199 entitled "List of Bulletins of the Agricultural Experiment Stations for the Calendar Years 1927 and 1928," has been completed. This supplement, which will appear in the Miscellaneous Publication series, contains approximately 200 more items than were contained in the previous supplement. The library has also compiled a list, with index, of the titles of circulars and other series published by the State agricultural experiment stations. It is hoped that this may later be issued as a printed publication. A list of the titles of articles reporting the results of experimental work in the stations which have appeared in scientific and technical journals during 1927 and 1928 is in preparation.

In the Forest Service library, a bibliography on forest economics was prepared and mimeographed for general distribution. Short lists were also prepared on boxwood, Christmas trees, dwarfing of trees, pencil cedar, prairies, and other subjects. The list of current literature indexed in the library was issued bimonthly in mimeographed form.

The Bureau of Plant Industry library continued to issue Botany—Current Literature, and Agronomy—Current Literature. The List of Books for Plant Study prepared by Alice C. Atwood and published in 1927 as Circular 14 of the Wild Flower Preservation Society, was revised and reissued in April, 1929. The Wild Flower Preservation Society will also publish a list of State floras of a popular

type compiled by Miss Atwood and annotated by S. F. Blake of the bureau. A list entitled "Cotton: Partial List of Publications in English, Exclusive of Publications on Diseases and Pests and Publications of the State Experiment Stations, 1926–1928," compiled by Marjorie F. Warner, was issued as a supplement to Agricultural Library Notes, vol. 4, No. 1–2. This brought up to date the original list compiled by Emma B. Hawks, associate librarian of the department, and published in 1926. The work on a bibliography on genetics in relation to plant breeding has been nearly completed during the past year, and it is planned to issue it in mimeographed form in the near future.

In the Bureau of Public Roads the following bibliographies were prepared and issued in mimeographed form:

Bibliography on methods of curing concrete. Compiled by Mildred Wilson. 18 p.
Selected list of books and periodicals on road construction. 6 p.
Partial bibliography on highway finance. Compiled by Mildred Wilson. 118 p.
Partial list of references on highway maintenance. Compiled by Dorothy J. Wilks. 118 p.
Annotated index to articles on highway safety and allied subjects. Prepared for the committee on causes and prevention of highway accidents, highway research board, by the staff of the library. 338 p.
Partial list of references on toll bridges. Compiled by Mildred Wilson. 9 p.

In addition, the weekly annotated list of current literature, Highways and Agricultural Engineering, was issued regularly. As many inquiries have been received regarding publications appearing in this list, the library issued during the year a list of publishers and prices of magazines most frequently appearing in the lists. This was issued in mimeographed form.

BUREAU AND DIVISION LIBRARIES

A list of the bureau libraries and various data in regard to them will be found in Table 12. Cataloguing statistics are included in Table 5. Statistics of circulation are given in table 8. Other activities such as reference work, bibliographical work, legislative work, etc., have been described in the body of the report under these headings.

In addition to their regular library work, several of the bureau libraries carry on work which may be considered as affiliated activities rather than strictly library work. As explained in last year's report, the Bureau of Agricultural Economics library has charge of what are called the foreign files. These consist of consular reports, commerce reports, market reports, clippings, and mimeographed reports, from various foreign Governments received through the State Department. The total number of such reports and clippings received during the past year was 21,359. The total number circulated during the year was 18,896. Two special temporary jobs assigned to the Bureau of Agricultural Economics library during the past year were the compilation of a scrap book of comment on the work of the bureau by the press, and the indexing of the division research projects of the bureau. The Bureau of Dairy Industry library continued to have charge of the photographic files and the correspondence files of the bureau. In the Bureau of Entomology the librarian has charge of the bureau mailing lists. In the libraries of the Bureaus of Agricultural Economics, Animal Industry, Chemistry and Soils, Entomology, Forest Service, Plant Industry, and Public Roads, records are kept of books and periodicals ordered for the field offices and laboratories. The work in connection with all of these activities was heavy during the year

During the past year an addition was made to the branch libraries of the department, a library having been established for the Division of Agricultural Engineering of the Bureau of Public Roads. The librarian took charge on June 1, after experience in the main library. The Division of Agricultural Engineering is concerned with agricultural engineering, irrigation, drainage, farm practice, farm management, electricity on the farm, and related subjects Although a number of the publications going to the Public Roads library are of interest both to the highway engineers and the agricultural engineers, for the most part the subjects are separately treated. Furthermore, the Division of Agricultural Engineering is housed in a separate building. For these reasons a need was felt for a separate collection and a separate service for the division. Part of the collection of the bureau was transferred to the division, which has relieved the crowded condition of the bureau library. Additional space was also obtained for the bureau library through the assignment to it of an adjoining room containing 185 square feet which enabled the bureau library to install additional shelving and additional filing cabinets.

COOPERATION WITH OTHER LIBRARIES

In continuation of the library's policy of affording opportunity to librarians and library assistants from other agricultural libraries to have experience in this library, arrangements were made during the past year for Lydia Friedemann, Librarian of the Oklahoma Agricultural Experiment Station, to work in the library for about two months, beginning the middle of June, while taking the library course at George Washington University. Another assistant, Vittorio Camerani, from the library of the International Institute of Agriculture, Rome, also worked in the library for a few weeks, beginning in June.

Agricultural Library Notes, the mimeographed publication of the library, issued in cooperation with the land-grant college and experiment-station libraries, was continued throughout the year, six numbers having been issued.

The library again cooperated with the library-science division of George Washington University in providing two lectures on the library work of the department in connection with the course in library administration given by the university.

LIBRARY ASSOCIATIONS MEETINGS

The American Library Association and the Special Libraries Association met in Washington, May 13–18, 1929. The agricultural-libraries section of the American Library Association held two sessions, May 13 and 15, in the conference room of the Bureau of Agricultural Economics. The librarian of the bureau was secretary and was reelected for the year 1929–30. At the first of the two meetings the librarian of the department presented a paper entitled "The United States Department of Agriculture and Its Relations to Agricultural Libraries." At this meeting also the announcement was made of the third award of the Eunice Rockwood Oberly memorial prize, the prize being awarded to Mrs. Annie M. Hannay, of the Bureau of Agricultural Economics, for her bibliography entitled "Control of Production of Agricultural Products by Governments" (Agricultural Economics Bibliography No. 23). Honorable mention was also given Carrie B. Sherfy, librarian of the Bureau of Dairy Industry, and Mrs. Nell Smallwood, of the bureau library staff, for their bibliography entitled "Bibliography on Ice Cream Up To and Including the Year 1926" (Bibliographical Contribution No. 17), and Margaret T. Olcott, Assistant Librarian of the Bureau of Agricultural Economics, for her bibliography entitled "Taxation and the Farmer" (Agricultural Economics Bibliography No. 23). The librarian of the department prepared for distribution at the meeting a mimeographed description of the library and its resources entitled "The Library of the United States Department of Agriculture, a Brief Description of Its Resources, Organization, and Work." Immediately following the second meeting a luncheon was given for the agricultural-libraries section by the library staff of the department with the cooperation of various bureaus and offices of the department.

At a meeting of the Special Libraries Association, May 14, a paper entitled "Current Inter-American Highway Research" was given by O. Louise Evans, librarian of the Bureau of Public Roads of the department.

FOREIGN VISITORS

An increasing number of foreign visitors are making use of the library, some remaining for several weeks' work. In the main library and the bureau libraries there were visitors during the past year from Australia, China, Czechoslovakia, Germany, Japan, Mexico, Russia, South Africa, Spain, and Switzerland, several of whom remained for some weeks. Following the Fourth International Entomological Congress at Ithaca, a number of foreign entomologists visited the Bureau of Entomology library.

LIBRARY QUARTERS

The library shelves have been in bad condition for the past two years, for they have been filled to overflowing, particularly in the basement. The additional 1,605 square feet of space in the basement which became available in July, 1929, will therefore bring much-needed relief. With this additional space the library will have a total of 21,578 square feet comprising all of two floors of the Bieber Building with the exception of the general freight room of the building in the basement.

LIBRARY FINANCES

The receipts and expenditures of the library for the past 10 years are given in Table 14. The increases which were provided for the fiscal year 1929 were $3,720 for salaries and $1,200 for news-

papers. The subscriptions for the latter had formerly been paid from the fund for the miscellaneous expenses of the department.

LIBRARY STAFF

The increases in Government salaries provided by the Welch bill have helped the library, in common with other offices. The number of permanent employees carried on the staff of the main library at the close of the fiscal year was 37. In addition, there was one temporary employee. The number employed by the bureau and office libraries was 61. Further details are contained in Table 13. The library suffered the loss during the year of one of its most expert cataloguers, who resigned to accept a higher salary in the Library of Congress. The library also had 5 other resignations, 2 of them junior library assistants, 1 a minor library assistant, 1 a senior typist and 1 an assistant messenger. There were no changes in the administrative positions of the bureau libraries, with the exception of the resignation of the assistant librarian of the Bureau of Chemistry and Soils. This position is not yet filled.

Staff meetings, including the staffs of both the main library and the bureau libraries, were held each month from October to June.

Grateful acknowledgment is made to the members of the library staff of the department for their zeal and loyalty, and to the administrative officials, bureaus, and offices of the department for their support and cooperation. These together have made possible the progress of the library.

TABLE 1.—*Accessions, 1928 and 1929*

	1928	1929
Purchases:		
Volumes	2,098	2,288
Pamphlets	158	144
Maps and charts	37	4
Serials and continuations	649	639
Total	2,942	3,075
Gifts:		
Volumes	1,600	1,260
Pamphlets	1,460	1,215
Maps	73	86
Continuations	5,519	5,992
Total	8,652	8,553
From binding periodicals and serials:		
Permanently bound	2,267	1,372
Binders	1,667	1,126
Total	3,934	2,498
New current periodicals	277	228
Total accessions	15,805	14,354

TABLE 2.—*Record of material catalogued, 1928 and 1929*

	1928	1929
Volumes	3,698	3,548
Pamphlets	1,618	1,359
Maps and charts	110	90
Continuations and serials	6,168	6,631
Volumes received from bindery	2,267	1,372
Volumes in binders	1,667	1,126
Additions to binders	[1]	211
Current entries	[1]	228
Changed titles	59	77
Total	15,587	14,642
Pamphlets (author cards only)	294	201
Reprints (author cards only)	5,132	3,241

[1] Figures omitted in 1928 report.

TABLE 3.—*Uncatalogued material, 1928 and 1929*

	1928	1929
Purchases:		
Volumes	214	22
Pamphlets	94	10
Continuations		4
Gifts:		
Volumes	897	677
Pamphlets	1,451	1,343
Continuations	59	77
Total	2,715	2,133

TABLE 4.—*Record of titles prepared for printing by Library of Congress in "Agr." series, fiscal years 1928 and 1929*

	Prepared		Printed	
	1928	1929	1928	1929
Accessions and recatalogued books	1,031	1,643	907	1,640
Department publications	388	359	429	381
Agricultural periodicals	94	67	94	67
Total	1,513	2,069	1,430	2,088

TABLE 5.—*Number of cards added to the general and special catalogues of the libraries of the department, 1928 and 1929*

Library	1928	1929
Main Library, general catalogue	[1] 20,346	[2] 25,376
Bureau of Agricultural Economics	10,428	14,346
Bureau of Animal Industry	[3]	[3]
Bureau of Chemistry and soils	2,272	1,346
Bureau of Dairy Industry	5,991	1,708
Bureau of Entomology	9,151	10,773
Office of Experiment Stations	4,223	5,682
Forest Service	8,760	8,000
Bureau of Home Economics	5,064	3,251
Bureau of Plant Industry	30,143	36,794
Bureau of Public Roads	11,373	16,946
Total	107,756	124,222

[1] Net addition, cards added being 22,382 and cards withdrawn 2,036.
[2] Net addition, cards added being 28,910 and cards withdrawn 3,534.
[3] Figures not available.

TABLE 6.—*Record of periodicals currently received, 1928 and 1929*

	1928	1929
Number of different periodicals received by purchase	1,130	1,194
Number of different periodicals received by gift and exchange	2,553	2,742
Total number of different periodicals received	3,683	3,936
Number of additional copies purchased	233	207
Number of additional copies received by gift and exchange	204	172
Total number of periodicals purchased, including duplicates	1,363	1,401
Total number of periodicals received by gift and exchange, including duplicates	2,757	2,914
Grand total of periodicals received by purchase, gift and exchange including duplicates	4,120	4,315
Number of different dailies received	78	79
Number of extra copies purchased	39	41
Total dailies received, including duplicates	117	120

NUMBER OF CURRENT PERIODICALS HANDLED DAILY DURING THE MONTHS OF APRIL AND MAY, 1928 AND 1929

	Total		Daily average	
	1928	1929	1928	1929
Received by mail	12,158	12,533	238.39	241.11
Received from circulation	12,890	12,894	252.74	247.96
Special numbers charged	1,811	1,723	35.51	33.13

TABLE 7.—*Record of binding, 1928 and 1929*

	1928	1929
Books and periodicals sent to bindery	2,480	2,193
Volumes laced into binders	2,757	1,253
Current serials added to binders	1,167	1,385
Pamphlets stapled in binders	1,150	1,019

TABLE 8.—*Combined statistics of circulation, 1928 and 1929*

Bureau or office library	To individuals		To main library		To branch libraries		Total		Current periodicals	
	1928	1929	1928	1929	1928	1929	1928	1929	1928	1929
Main library	20,219	20,038			26,718	26,768	46,937	46,806	[1]	[1]
Agricultural Economics	13,327	13,802	979	1,049	[1]	101	14,306	14,952	[1]	[1]
Animal Industry	2,097	2,233	240	189	91	124	2,428	2,546	32,839	31,226
Chemistry and Soils	7,676	7,785	998	1,028	42	87	8,716	8,900	36,114	37,386
Dairy Industry	2,121	1,987	91	100	66	41	2,278	2,128	22,099	22,372
Entomology	3,052	3,004	511	652	11	12	3,584	3,668	5,062	5,759
Experiment Stations	[1]	[2] 2,116	[1]	[1]	[1]	[1]	[1]	[1]	[3] 40,000	[2] 53,502
Forest Service	2,406	2,230	482	498	2		2,890	2,728	8,046	7,874
Home Economics	[2] 2,718	3,427	[2] 374	316	[1]	[1]	[2] 3,092	3,743	6,388	8,124
Plant Industry	[4]	[4]	[4]	[4]	[4]	[4]	[4]	[4]	37,620	34,504
Public Roads	2,696	2,901	412	481	[1]	[1]	3,108	3,382	12,741	14,233
Total	56,322	59,523	4,087	4,313	26,930	27,133	87,339	88,853	200,909	214,980

[1] Figures not available.
[2] Figures for September, 1927–June, 1928.
[3] Approximate figures.
[4] The Bureau of Plant Industry library does not maintain a collection of books, as it is in close proximity to the main library. The circulation of books to members of the bureau is, therefore, included with those for the main library, but circulation figures are available for current periodicals, as this circulation is handled in the Bureau of Plant Industry library.

TABLE 9.—*Books borrowed from other libraries during 1929*

In Washington		Outside of Washington	
American Red Cross	3	American Geographical Society	1
Bureau of American Ethnology	4	American Institute of Banking	1
Bureau of Education	8	American Museum of Natural History	3
Bureau of Fisheries	8	Arnold Arboretum	3
Bureau of Mines	2	Chemical Abstracts Office	3
Bureau of Railway Economics	8	Cornell University	5
Bureau of Standards	69	Harvard University	1
Catholic University of America	2	Iowa State College	1
Chamber of Commerce of the United States	1	Johns Hopkins University	5
Department of Labor	4	Lloyd Library	3
Department of State	9	Medical and Chirurgical Faculty, Baltimore, Md	1
Federal Reserve Board	2	Museum of Comparative Zoology	1
Geological Survey	73	New York Academy of Medicine	2
Hygienic Laboratory	22	New York College of Agriculture	2
Interstate Commerce Commission	2	New York State Library	1
Library of Congress	3,720	Rockefeller Foundation, New York	1
National Museum and Smithsonian	93	Rockefeller Institute, New York	1
Pan American Union	8	University of California	1
Patent Office	125	University of Chicago	1
Public Health Service	11	University of Illinois	1
Public library	22	University of Minnesota	2
Surgeon General's Office	457	University of Wisconsin	1
United States Army Engineer's School	1		
United States Naval Observatory	2		
War Department—Ordnance	1		
Weather Bureau	67		
Total	4,724	Total	41

Largest number of books borrowed from other libraries on any day	46
Average number of books borrowed from other libraries daily	15
Largest number of books borrowed from other libraries in any month	518
Smallest number of books borrowed from other libraries in any month	308
Average number of books borrowed from other libraries monthly	397
Total number of books borrowed from libraries in and outside of Washington	4,768

TABLE 10.—*Interlibrary loans outside of Washington, classified by institutions, 1928 and 1929*

Borrowers	1926	1927	1928	1929
Land-grant colleges and experiment stations	1,017	1,195	1,421	1,186
United States Department of Agriculture workers stationed outside of Washington	411	461	525	465
Colleges and universities other than land-grant colleges	124	112	162	242
Other scientific institutions	210	220	207	228
Business firms	48	82	82	136
Public libraries and miscellaneous	43	88	35	73
Total	1,853	2,158	2,432	[1] 2,330

[1] In addition to the 2,330 books and periodicals lent to borrowers outside of the city last year, 230 photostatic copies and 18 typed copies of articles were supplied, making a total of 2,578 loans for the year, a decrease o 1108, as compared with those of 1928.

TABLE 11.—*Interlibrary loans outside of Washington, D. C., 1920–1929*

United States (States, Territories, and island possessions) and foreign countries	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929	Total
United States:											
Eastern—											
Connecticut	7	13	5	5	10	48	53	24	36	24	225
Maine	3	1	------	1	12	8	1	3	1	10	40
Massachusetts	37	16	34	37	30	62	62	67	92	116	553
New Hampshire	6	9	11	22	12	6	1	21	19	12	119
New Jersey	49	89	63	107	75	92	78	68	106	67	794
New York	85	81	117	101	136	149	158	188	174	175	1,364
Pennsylvania	30	51	37	35	60	75	65	35	108	97	593
Rhode Island	12	5	8	------	1	15	18	4	6	8	77
Vermont	3	7	12	11	20	14	19	43	14	46	189
Total	232	272	287	319	356	469	455	453	556	555	3,954
Central											
Illinois	23	20	17	13	6	25	44	69	27	56	300
Indiana	13	38	7	32	24	23	41	38	58	25	299
Iowa	22	72	59	69	82	76	13	38	42	23	496
Kansas	22	3	23	15	14	18	11	30	14	14	164
Michigan	17	50	24	41	44	39	40	30	63	46	394
Minnesota	89	88	44	60	59	70	77	62	47	66	662
Missouri	10	6	22	21	30	37	54	32	12	42	266
Nebraska	15	7	7	14	10	25	23	33	26	29	189
North Dakota	5	14	10	8	15	10	15	5	15	6	103
Ohio	30	32	35	32	89	86	139	187	161	143	934
South Dakota	3	------	3	------	1	1	------	1	1	2	12
Wisconsin	2	48	63	35	33	88	67	55	74	63	528
Total	251	378	314	340	407	498	524	580	540	515	4,347
Southern—											
Alabama	10	17	5	6	8	3	13	11	4	8	85
Arkansas	19	32	21	24	23	20	29	47	51	48	314
Delaware	30	21	28	35	84	103	78	75	63	102	619
Florida	7	5	13	33	73	80	73	134	107	114	639
Georgia	6	12	31	15	14	31	35	43	34	44	265
Kentucky	15	13	30	34	49	23	16	24	8	31	243
Louisiana	5	5	15	15	10	13	17	13	14	65	172
Maryland	21	24	17	66	117	65	115	85	105	137	752
Mississippi	------	4	2	2	5	1	2	18	3	5	42
North Carolina	6	26	43	27	48	61	39	64	40	43	397
Oklahoma	1	7	8	5	1	13	15	40	56	31	177
South Carolina	2	12	11	15	22	20	30	26	34	27	199
Tennessee	10	11	12	33	8	8	7	3	7	3	102
Texas	4	21	14	19	19	3	26	17	18	43	184
Virginia	19	46	28	38	40	52	47	109	48	65	492
West Virginia	10	13	15	13	15	16	30	15	18	12	157
Total	165	269	293	380	536	512	572	724	610	778	4,839
Western—											
Arizona	4	23	------	1	11	20	5	20	34	18	136
California	43	16	18	29	52	47	54	53	64	87	463
Colorado	10	18	9	37	13	9	15	39	31	17	198
Idaho	8	1	7	1	4	4	12	24	15	2	78
Montana	13	7	6	38	26	17	25	37	26	33	228
New Mexico	6	11	------	1	------	2	2	8	2	------	32
Nevada	1	------	2	1	------	------	------	------	------	------	4
Oregon	19	53	30	15	6	8	38	35	91	28	323
Utah	14	19	22	12	45	28	57	47	90	43	377
Washington	12	31	4	7	17	22	39	30	33	49	244
Wyoming	4	6	11	3	7	21	3	5	12	8	80
Total	134	185	109	145	181	178	250	298	398	285	2,163
Territories and island possessions:											
Alaska	1	------	1	------	------	------	------	1	------	1	4
Canal Zone	------	1	------	------	------	------	------	------	------	------	1
Guam	1	------	------	------	------	------	1	------	------	------	2
Hawaii	------	------	------	------	------	1	------	------	------	1	2
Porto Rico	14	32	9	9	20	17	22	13	279	115	530
Total	16	33	10	9	20	18	23	14	279	117	539
Foreign countries:											
Canada	------	------	------	------	------	------	24	40	44	70	178
Cuba	------	------	1	------	------	------	------	3	------	------	4
Other countries	1	2	1	------	5	12	5	2	5	10	43
Total	1	2	2	------	5	12	29	45	49	80	225
Grand total	799	1,139	1,015	1,193	1,505	1,687	1,853	2,114	2,432	2,330	16,067

TABLE 12.—*Statistics of bureau libraries* [1]

Bureau or office	Employees	Books	Pamphlets	Periodicals currently received	Registered borrowers	Registered borrowers to whom periodicals are circulated	Shelving	Area occupied by library
	Number	*Number*	*Number*	*Number*	*Number*	*Number*	*Lin. ft.*	*Sq. ft.*
Agricultural Economics	18	[2] 52,833		1,759	457	140	4,365	4,728
Animal Industry	2	([3])		560	72	64	15	540
Animal husbandry division		[4] 4,200	([5])	250	50	([5])	([5])	([5])
Chemistry and Soils	3	10,385		577	333	168	1,770	1,000
Fixed nitrogen research laboratory	2						([5])	([5])
Dairy Industry	4	660	4,900	373	68	62	180	400
Entomology	3	10,752	12,550	948	136	36	1,583	1,000
Bee culture laboratory	1							
Experiment Stations	8	4,055	63,958	1,207	89	55	1,847	1,702
Forest Service	1	[2] 25,638		160	154	72	1,227	1,132
Home Economics	2	[4] 2,000	([5])	325	52	42	782	841
Plant Indsutry	11	([3])		698	([3])	179	140	650
Public Roads	4	[4] 7,361	13,100	285	117	125	1,389	912
Agricultural engineering	1			179	25	18	230	256

[1] The Weather Bureau library is administered separately, with the exception that the books and periodicals are purchased from the appropriation of the library of the department, the sum of $1,000 being set aside each year for this purpose.
[2] Includes pamphlets.
[3] Does not maintain a collection of books.
[4] Approximate figures.
[5] Figures not available.

TABLE 13.—*Library staff of the department*

Library	Administrative positions	Assistants	Clerks	Translators	Messengers	Charwomen	Total
Main library	4	22	3		5	3	37
Bureau and office libraries:							
Agricultural Economics	1	12	4		1		18
Animal Industry	1	1					2
Animal husbandry division			1				1
Chemistry and Soils	1	1		1			3
Fixed nitrogen		1	1				2
Dairy Industry	1	1	2				4
Entomology	1	2					3
Bee culture laboratory			1				1
Experiment Stations	1	6			1		8
Forest Service	1						1
Home Economics	1	1					2
Plant Industry	1	6	3		1		11
Public Roads	1	2	1				4
Agricultural engineering		1					1
Total	10	34	13	1	3		61
Grand total	14	56	16	1	8	3	98

TABLE 14.—*Financial statement, 1920 to 1929*

RECEIPTS

	Fiscal year—									
	1920	1921	1922	1923	1924	1925	1926	1927	1928	1929
Source:										
Library appropriation—										
Salaries	$32,160.00	$32,880.00	$30,060.00	$32,660.00	$32,660.00	$40,000.00	$38,680.00	$54,680.00	$60,000.00	$69,100.00
General expenses	18,000.00	22,000.00	21,400.00	25,000.00	30,000.00	30,960.00	29,500.00	29,500.09	24,180.00	26,580.00
Total	50,160.00	54,880.00	51,460.00	57,660.00	62,660.00	70,960.00	68,180.00	84,180.00	84,180.00	95,680.00
From department printing and binding fund	9,210.70	7,031.20	14,549.59	7,460.64	10,621.26	13,171.04	9,983.30	13,173.75	10,045.07	
Main library salaries paid by bureaus	1,467.50	5,221.67	7,560.02	10,472.89	12,257.50	15,117.84	16,521.50			
Grand total	60,838.20	67,132.87	73,569.61	75,593.53	85,538.76	99,248.88	94,684.80	97,353.75	94,225.07	

EXPENDITURES

Books and serials	$9,246.05	$9,439.69	$9,998.58	$11,182.48	$11,138.26	$13,582.31	$14,710.31	$14,750.47	$13,093.14	[1] $14,801.18
Periodicals	5,231.48	6,039.62	6,353.68	7,008.48	6,916.54	6,937.19	7,184.29	7,517.97	8,845.99	9,059.06
Maps	62.04									
Index cards	112.23	178.51	141.88	172.45	147.37	162.45	169.30	137.88	155.41	165.75
Furniture, shelving, and miscellaneous equipment	293.16	2,525.94	29.91	2,435.20	1,738.15	1,908.83	404.77	476.86	1,133.24	821.04
Traveling expenses	48.52	219.72	190.23	177.52	971.06			78.44	108.04	
Freight, express, and drayage	93.07	56.94	62.90	13.95	21.51	44.97	42.29	16.52	12.47	19.48
Supplies and repairs	539.58	518.50	566.76	1,459.67	1,136.98	1,015.01	971.84	1,122.24	[2] 1,077.00	[2] 1,349.09
Truck service			9.87	52.78	38.89	81.81	85.80	78.87	95.40	107.97
Newspapers				94.16	99.32	97.80	99.60			809.90
Salaries (statutory)	29,106.85	27,013.25	30,059.01	32,219.04	31,960.67	39,799.96	38,613.92	54,066.54	59,655.09	68,526.70
Salaries (miscellaneous)	2,356.00	2,921.35	3,931.62	2,394.35	7,774.99	6,194.51	5,080.00	5,319.96		
Total	47,088.98	48,913.52	51,344.44	57,210.08	61,943.74	69,824.84	67,362.12	83,565.75	84,175.78	95,660.17
Printing	348.56	342.34	1,826.01	579.03	567.97	444.47	477.32	327.96	438.25	
Binding	8,862.14	6,688.86	12,723.58	6,881.61	10,053.29	12,726.57	9,505.98	12,845.79	9,607.82	
Main library salaries paid by bureaus	1,467.50	5,221.67	7,560.02	10,472.89	12,257.50	15,117.84	16,521.50			
Grand total	57,767.18	61,166.39	73,454.05	75,143.61	84,822.50	98,113.72	93,866.92	96,739.50	94,221.85	
Credit received for duplicates exchanged with book dealers and libraries					954.75	604.35	216.35	653.68	147.30	
Gifts					12.94	10.75				

[1] Outstanding liabilities for books, periodicals, and serials, $14.83.

[2] Itemized as shown on p. 13.

TABLE 14.—*Financial statement, 1920 to 1929*—Continued

EXPENDITURES—Continued

Supplies	1928	1929
Cleaning and toilet supplies	$104.76	$107.62
Stationery	107.11	208.67
Miscellaneous office supplies	488.76	264.74
Binding material	49.38	126.32
Total	750.01	707.35

Repairs	1928	1929
Repairs and alterations:		
Carpentry work	$65.43	$160.74
Electrical work	31.46	191.04
Typewriter repairs	20.92	27.19
Painting	135.05	186.59
Miscellaneous repairs	74.13	76.18
Total	326.99	641.74

LIBRARY

U. S. GOVERNMENT PRINTING OFFICE: 1929

U.S. DEPT. OF THE
OFFICE OF EXPERIMENT STATIONS
DEC 14 1929
EXPERIMENT STATION FILE

For Release to Afternoon Papers of December 3, 1929

REPORT OF THE CHIEF OF THE BUREAU OF PLANT INDUSTRY

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PLANT INDUSTRY,
Washington, D. C., August 31, 1929.

SIR: I have the honor to submit herewith a report of the work of the Bureau of Plant Industry for the fiscal year ended June 30, 1929.

Respectfully,

WM. A. TAYLOR,
Chief of Bureau.

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

WORK AND ORGANIZATION

The Bureau of Plant Industry is primarily a research organization devoted to the investigation of problems of plant production. Its general objective is the reduction of the heavy waste of human energy, time, and money resulting from lack of knowledge of the essential biological facts and processes involved in plant growth and plant utilization. This work includes crop improvement by breeding and selection; the introduction of new crops by means of seeds and plants procured through foreign exploration; experimentation in methods of culture and rotation systems adapted to irrigation, dry-land, and other systems of agriculture; investigations in handling, storing, shipping, processing, or otherwise utilizing plants or plant products; and diagnosis and control of the many kinds of plant diseases. The solution of such problems involves widely varied agronomic, horticultural, physiological, biochemical, and technological research in laboratory and field, often including the continuance of particular experiments for extended periods of years, to determine the essential facts upon which to base sound practice.

As our agriculture becomes older, and especially as intercommunication between production areas, both domestic and foreign, becomes more frequent and extensive, plant diseases as well as insect pests increase in numbers and in destructiveness. More plant diseases have apparently been spread to new regions in the last century than during the many preceding centuries.

Recognition of this existing condition and of the certainty that it will become more serious as present agricultural production trends continue makes necessary increasingly intensive attack upon plant-disease problems affecting a wide range of crops. Close correlation of plant breeding and cultural practice research is recognized as increasingly important. To facilitate such correlation with respect to work on horticultural crops generally, the administration of the more important activities bearing on such crops has been grouped in a single office, that of horticultural crops and diseases, during the fiscal year. It is believed that this realignment, through which the general direction of the work will be more centralized, will relieve the project leaders of much routine work, thus enabling them to devote more of their individual time and energy to the exacting scientific research problems which they are attacking.

The work of the bureau is carried on by the following organization:

Office of the Chief	William A. Taylor, chief of bureau. K. F. Kellerman, associate chief of bureau. H. E. Allanson, assistant chief of bureau.
Arlington Experiment Farm	E. C. Butterfield, senior horticulturist and superintendent in charge.

Biophysical Laboratory	G. N. Collins, principal botanist in charge.
Blister Rust Control	S. B. Detwiler, principal pathologist in charge.
Botany	F. V. Coville, principal botanist in charge.
Cereal Crops and Diseases	C. R. Ball, principal agronomist in charge.
Citrus Canker Eradication	Directed by associate chief of bureau.
Cotton, Rubber, and Other Tropical Plants	O. F. Cook, principal botanist in charge.
Drug and Related Plants	W. W. Stockberger, principal physiologist in charge.
Dry-Land Agriculture	E. C. Chilcott, principal agriculturist in charge.
Egyptian Cotton Breeding	T. H. Kearney, principal physiologist in charge.
Fiber Plants	L. H. Dewey, senior botanist in charge.
Forage Crops and Diseases	R. A. Oakley, principal agronomist in charge.
Foreign Plant Introduction	K. A. Ryerson, principal horticulturist in charge.
Forest Pathology	Haven Metcalf, principal pathologist in charge.
Gardens and Grounds	J. W. Byrnes, assistant in charge.
Horticultural Crops and Diseases	E. C. Auchter, principal horticulturist in charge.
Mycology and Disease Survey	C. L. Shear, principal pathologist in charge.
Nematology	N. A. Cobb, principal nematologist in charge.
Phony Peach Eradication	Directed by associate chief of bureau.
Seed Laboratory	Edgar Brown, principal botanist in charge.
Sugar Plants	E. W. Brandes, principal botanist in charge.
Tobacco and Plant Nutrition	W. W. Garner, principal physiologist in charge.
Western Irrigation Agriculture	C. S. Scofield, principal agriculturist in charge.

Some of the noteworthy results of the bureau's investigations during the past year are briefly described in the following pages. A more comprehensive idea of the scope of the bureau's researches may be obtained from the list of articles published by the specialists of the bureau during the year, reporting in detail the progress of their investigations. A list of these publications is appended.

The appropriations available for the work of the bureau for the year were apportioned, as authorized by law, to the several types of work under way, approximately as follows:

Research work	$3,688,087
Control and eradication work	880,255
Regulatory work	31,171
Total	4,599,513

FRUITS

APPLES

Investigations have shown that, as root stocks for use in propagation, seedlings of some varieties of apple, of which Baldwin, Summer Rambo, Stark, Smokehouse, Paragon, and the Transcendent crab are examples, are inferior and have little value. The seedlings of most varieties, however, are satisfactory through the nursery period. Obviously the influence of the root stock, if any, on such features as the productiveness of the mature tree and its longevity can be determined only through many years of study.

In the experiments on the removal of spray residues it was found that the addition of lime to the lead-arsenate spray is a practical preventive for arsenical injury in the washing process. Where abundant fresh water is not available for rinsing in connection with the washing treatment it was found that injury from soluble arsenic could be effectively and economically prevented by the use of a lime-water rinse. The relation of temperature of the cleaning solution to injuries on the apples has been determined.

Further studies on the control of crown gall with organic-mercury compounds have demonstrated that the control of this disease on rooted clon cuttings may be accomplished by dipping the cuttings in such a compound. Studies of a certain type of hairy root on nursery apple trees have shown that it is caused by a bacterium closely related to the crown-gall organism. This bacterium differs from the true crown-gall bacterium in motility and in character of growth on different synthetic media. The use of nurserymen's tape as a wrapper for the grafts eliminates about two-thirds of the loss from malformed unions of stock and scions. The overgrowths and excess callus development can be largely prevented by care in fitting and matching tongue grafts, while the careful use of wedge grafts has been even more successful.

BERRIES

BLUEBERRIES

The long-continued work of the bureau in the breeding of improved blueberries has now resulted in the production of a blueberry fifteen-sixteenths of an inch in diameter. In addition, field pollination of blueberries has been carried out for the first time at two blueberry-growing stations in New Jersey, and several thousand seedlings so produced are now being grown in department greenhouses in Washington. This demonstration of the fact that blueberry crosses can be made successfully under field conditions opens up new possibilities in the production of new varieties on a scale much larger than is possible under greenhouse conditions, under which

all the crosses have hitherto been made.

The work on blueberry diseases was directed chiefly toward testing the new varieties for resistance to fruit rots; that is, for keeping quality. Six of the most promising varieties were tested for keeping quality at 30° C. (86° F.) for one week and in commercial cold storage at approximately 2° C. to 4° C. (35.6° to 39.2° F.) for one month. Not only was a striking difference in the keeping quality of the several varieties revealed, but it was demonstrated that the keeping quality at 30° C. during a 7-day period serves as a reliable index of keeping quality in cold storage for a much longer period.

CRANBERRIES

False blossom of the cranberry is still the most pressing cranberry problem. The most important line of attack is a search for resistant varieties. Several promising varieties were secured from the wild bogs of Wisconsin and others from old bogs of native vines in New Jersey. These are being propagated, and will be tested for yield and keeping quality as well as resistance to false blossom before being offered to growers. In the course of the search for new varieties in Wisconsin, false blossom was found on five wild bogs in northeastern Wisconsin, more than 100 miles from any place where the disease had been previously reported. Undoubted cases of false blossom were found on the moss cranberry (*Vaccinium oxycoccus*). This is the first case of the disease on any host other than *V. macrocarpon*.

STRAWBERRIES

The strawberry breeding work has been augmented the current season in the eastern United States by some 50,000 seedlings from hand-made crosses. About 21,000 seedling crosses are also growing in the Northwest. Physiological studies on strawberries during the year have contributed information regarding root activity during the winter which gives a rational basis for certain cultural practices; the response of different varieties to controlled conditions, especially to varying lengths of day, explains the adaptability of some types to southern sections, and a critical study of fruit-bud formation has shown the difference in the behavior in this respect between the spring fruiting and the so-called everbearing varieties.

RASPBERRIES AND BLACKBERRIES

The breeding of raspberries and blackberries has yielded several selections which are considered sufficiently superior to varieties already in the trade to warrant their propagation for experimental introduction. The selections include three purple raspberries, especially desirable for canning and preserving, several black-cap varieties, and one blackberry cross.

CITRUS

IMPROVEMENT THROUGH BUD SELECTION

A very practical as well as a scientific aspect of the citrus bud selection work has been to determine whether the characteristics of the apparent sports or bud variations found in citrus varieties are, as a matter of fact, transmitted to progeny trees propagated from them. Hundreds of progeny trees from the bud variations have been propagated and grown under close observation. Detailed records have been kept of their production, the character of the fruit, and the peculiarities of the trees. These records are cumulative from year to year. In brief, progeny trees of practically all of the well-defined citrus bud variations that have been found have now been in bearing for several years, and detailed records have been compiled. The results show that without exception the foliage, fruit, and bearing characteristics of the variations are reproduced in trees propagated from them. Thus, a desirable mutation can be perpetuated; likewise, if a sport that is a deterioration from the type is unwittingly propagated it becomes disseminated and planted in commercial orchards. This has occurred frequently in the past.

An experiment carried on incidentally in connection with the bud-selection work so fully demonstrated the harm from heavy pruning and the advantages, by comparison, of light pruning that consists of little more than removing dead wood and keeping the top reasonably open, that the former practice in the Southwest of heavy pruning has been very largely discontinued. Moreover, the very general practice of growing nursery trees from selected buds has greatly simplified the pruning, since such trees as they come to maturity require much less pruning to keep them in good condition than do some of the strongly vegetative but unproductive types of tree.

ARTIFICIAL COLORING

In the artificial coloring of citrus fruits in Florida, investigations have shown that improper conditions, such as too high temperature, excessive doses of gas, and insufficient ventilation, adversely affect the subsequent keeping quality of the fruit and favor the development of molds, rots, and decays in transit and storage. The importance of close attention to the proper regulation of these conditions is emphasized.

HYBRIDS

No group of citrus hybrids is proving more interesting than the collection of hybrids of the tangerine orange and pomelo (grapefruit) known as tangelos. The bureau has now an entire new series of these bright colored, sprightly flavored oranges, maturing all the way from November to May or June. Some of them give every promise of being superior to the Sampson and Thornton tangelos for commercial culture. They will undoubtedly rank as "luxury fruits," offering no competition to standard citrus varieties. Extended field trials, of course, will be necessary to determine the value of these new tangelos under actual grove condition, before they can be recommended for commercial planting.

CANKER ERADICATION

For more than 13 years the Bureau of Plant Industry and the Gulf States have been engaged in a joint campaign to eradicate citrus canker, a bacterial disease of citrus fruits and trees, a disease which threatened the destruction of the citrus industry. The success of this campaign has been demonstrated in the reduction of new infections found each year.

Mississippi has not reported an infection since 1922 and Alabama has not reported an infection since 1927. It is now believed that these States are free from this disease, but in order that there may be no further spread of citrus canker, a close reinspection of all nurseries and properties in these States is being made.

Florida, with its large citrus holdings, now classes but 2 of the 515 properties found infected at various times as "infectious." These properties were found heavily infected in November, 1927. A third property in Florida rests under certain restrictions because of methods of cultivation, etc. No new infections have been reported from Florida.

Louisiana is still finding many scattered infections. During the past year it was necessary to destroy 36,166 grove and nursery trees scattered throughout nine parishes in the State because of this disease. The largest infections were found in Assumption, Lafourche, St. James, St. John, and Terrebonne Parishes. It is estimated that it will take at least three years to eradicate citrus canker completely from Louisiana.

After it had been thought that Texas was free from citrus canker, an infection was reported in February, 1929, from Angleton, where an orange and a grapefruit tree were found infected. The infection was on the leaves and in the early stages of development and on trees that had been planted about one year. The trees were destroyed and a thorough inspection of the entire district made, but no new infections were found.

Because of these scattered infections and the extreme infectiousness of citrus canker, in order to prevent a recurrence of an epidemic it will be necessary to maintain a systematic inspection of the entire southern citrus area for several years.

DATES

The establishment of date growing on a satisfactory commercial basis in the Southwest is the latest illustration of the possibility of bringing in new crops that do not compete with existing staples and so do not add to the problem of overproduction. Dates not only do not compete with the ordinary fruits grown in the United States, but they can be grown in regions where such fruits are not particularly successful. While commercial date growing in this country is at present restricted largely to a single variety, the famous Deglet Noor of North Africa, and largely to a single region, the Coachella Valley of California, experiments under way have shown that there are varieties with a much wider range of adaptability to climatic and cultural requirements than the Deglet Noor which should make it possible to extend commercial date growing into other regions.

During the year a first-hand study of the date varieties of the Mesopotamian region was made by specialists of the bureau with a view to securing varieties suited to some of our southwestern valleys where the occasional occurrence of untimely rains during the ripening season renders the North African varieties unsuited to commercial culture. Offshoots of a num-

ber of interesting and promising varieties were imported which will be tested under the conditions of the lower Rio Grande Valley in Texas in the hope of establishing the commercial production of this crop in that region.

GRAPES

Much information concerning many varieties of grapes previously untried under the conditions in American vinifera regions has been accumulated and in various ways disseminated to the growers. Dual-purpose varieties, especially those possessing high table and raisin qualities, appear to be of particular promise. During the past season a test was made of 16 little-known varieties each of which cured into excellent raisins and which also possess good table, shipping, and storage qualities.

In the preparation and handling of fruit juices there are a number of complicated problems. For instance, in the course of a study of the effects of pasteurization upon apple and grape juices, it was found that the rate and degree of precipitation of suspended material induced by heating could not be predicted from a knowledge of acidity, sugar content, or other data obtainable from the usual methods of analysis. It was found, however, that juices quite dissimilar in chemical composition but identical in hydrogen-ion concentration show like behavior when pasteurized. This discovery permits a physiochemical explanation of the behavior of juices in pasteurization and brings the results into line with what is known of the effect of hydrogen-ion concentration in jelly making. It also offers a solution for some of the difficulties encountered in commercial grape-juice manufacture.

PEACHES

Following the preliminary experiments maturing in 1927, it was definitely established in 1928 by more complete experimentation that the phony disease which has been devastating the orchards of central Georgia for several years is communicable from the roots of diseased trees to the roots of healthy trees. It had previously been found by repeated experiments impossible to communicate this disease from any part of the top of the tree, including the fruit. This discovery indicates that this malady belongs to the group of infectious diseases called virus diseases.

An intensive cooperative campaign has been inaugurated, to be conducted by the Bureau of Plant Industry and the Georgia Board of Entomology, for the prompt eradication by cutting of all trees found infected in the State of Georgia, and a quarantine to prevent the spread of the disease on the roots of nursery stock from the infected region to other sections has been established.

A spray containing zinc sulphate and hydrated lime in the experiments of 1928 decreased the losses from bacterial spot without injuring fruit and foliage and also made the leaves a deeper green and gave the fruit a somewhat better finish. This new zinc spray promises to be useful in the control of peach bacterial spot and marks an epoch not only in peach spraying but in the control of bacterial diseases, since, so far as known, this is the first time that a bacterial disease of plants has been brought under direct control by spraying.

Studies on the utilization of southern-grown peaches have developed methods of preparing and preserving peach pulp for use in ice cream and for other purposes which result in a very high-grade and acceptable product. Methods of canning the principal peach varieties grown in the South and East have been developed which it is believed will result, if applied, in a much better product than is commonly put out, at the same time avoiding some of the difficulties that have been sources of considerable financial loss. Among the latter is the determination of the relation of sulphur spray residues to the swelling of canned peaches and means of eliminating this trouble.

PEARS

Substantial progress has been made in determining the bearing habits of different pear varieties as influenced by conditions affecting tree growth, including pruning. Pruning that is done without due regard to these factors is likely to defeat the very purpose that it is intended to accomplish. The results of these studies will supply a rational basis for pruning under different conditions of tree growth.

Pear seedlings grown from Bartlett seeds, available in large quantities from canneries and dry yards in the Pacific Coast States, appear to have all of the nursery qualities of seedlings grown from imported French pear seed. In fact, such seedlings have made a more uniform growth than those from imported seed, and when

artficially inoculated with pear blight the Bartlett seedlings have shown no greater susceptibility to that disease than have those from French seed.

A study in transportation has dealt primarily with the effect on the fruit of loading the cars considerably more heavily than is the common practice. The regular load of a standard car is 520 boxes of pears. A comparison of cars so loaded with others containing 664 boxes, or an increase of about 27 per cent, was made. The cars were shipped from the Northwest to New York. Some of the pears were sold on arrival; others were held in storage there for two or three months. There was no appreciable difference in the condition of the fruit from the heavily and the lightly loaded cars, but the heavier loading results in an appreciable reduction in the cost of refrigeration and may make possible economies in other respects.

NUTS

ALMONDS

The breeding of almonds for better varieties has been in progress for several years and has begun to yield results. Five selections that possess qualities of special interest from a commercial standpoint have been made. One selection in particular was found in preliminary tests to possess superior flavor and blanching and salting qualities better than those of any variety now grown in California for these purposes. The kernel is a little too small and the shell somewhat lacking in texture, but the selection has enough of promise to warrant a wide test in the almond-growing districts of California.

PECANS

The results of stock tests thus far have not sustained a somewhat definitely fixed concept in the industry that seedlings of particular varieties are superior to others as stock for the nursery propagation of pecan varieties. On the other hand, there is but very little apparent difference in the value of seedlings of one variety as compared with those of another, so long as the nuts from which they grow are of medium size, well filled, and in a fresh condition.

Preliminary experiments with the pecan-scab fungus indicate that there are strains or physiologic forms of this fungus that attack the different pecan varieties with varying degrees of severity. The presence of these strains adapted to different varieties probably accounts for the successive spread of the pecan scab to different varieties in different sections of the country in recent years.

VEGETABLES

BEANS

Investigations recently completed have proved that baldhead, a disease of beans, which affects as high as 30 per cent of the seed of some varieties, is the result of injury to the embryo caused by the threshing machine. The snap beans in general are more liable to injury than the dry-shell beans.

In breeding for disease resistance over 1,400 selections were made in 1928, some of which show outstanding qualities for canning purposes, combined with a high degree of resistance to blight mosaic. One particular selection is a bush-type wax bean with a round, stringless pod and relatively free of fiber in the wall, which grows an erect bush and matures a large percentage of its pods at one time, making it peculiarly fitted for harvesting by a mechanical picker.

CELERY

Black-heart, a widespread and destructive disease of celery, has been found to be most destructive on soils with a low water-holding capacity and to be caused primarily by unbalanced water relations, with temperature and humidity playing a minor rôle. Some varieties show a marked resistance to the disease, while others are very susceptible.

The so-called brown-stem disease of celery, previously supposed to be physiologic in nature, and causing a browning and shrinking of the stalks and chlorosis of the foliage, occurs in large celery-growing sections of Florida. Recent investigations have shown that this is a transmissible disease of the mosaic type and that it is disseminated by aphids.

MELONS

In connection with the breeding of muskmelons for resistance to powdery mildew (*Erysiphe cichoracearum*), carried on in cooperation with the California College of Agriculture, some melons that are practically immune were obtained from India. These melons are useless commercially but are being used as breeding stock for crossing with commercial varieties. Some of them also showed decided

resistance but not immunity to downy mildew (*Peronospora cubensis*).

During the past year additional shipping tests of watermelons from south Georgia have demonstrated the possibility that, when insufficient dry bedding is used, a very considerable amount of injury may result if a residue of various chemicals is present on the floor of the freight cars. Salt, sodium nitrate, superphosphate (acid phosphate), ammonium sulphate, potassium sulphate, and potassium muriate caused the greatest injury. Thorough cleaning of the cars and the use of ample dry bedding effectively prevent damage.

ONIONS

It has been successfully demonstrated that the shrinkage of onion sets caused by neck rot can be greatly reduced by artificial curing in a forced-air current at a temperature of about 110° F. One company in Illinois cured about 8,000 bushels, with an estimated saving of about 1,500 bushels.

Resistance of colored onions to smudge and certain other storage diseases has been shown to be due to a toxic principle in the outer scales. Being soluble in water, this toxic substance can diffuse out of the scales into the soil, in which the fungus may be present, and inhibit infection.

PEANUTS

Eight years' study of the influence of age on the vitality and yielding quality of peanut seed indicates that the seed of the Improved Spanish and Valencia varieties can be kept for about six years without serious deterioration. By rigid selection of seed during several years of work it has been shown to be possible to develop large-seeded, high-yielding strains.

Three years' observations on the results of applying lime and gypsum to the soil have indicated no significant effects of either of these materials in the growing of peanuts under the conditions prevailing at Florence, S. C., where the work was carried on.

Several seasons' tests on the effect of handling and storing peanut seed in different ways and at different temperatures has shown a wide range of practical possibilities. There were no consistent differences in the germination or in yield of peanuts from shelled and unshelled seed, stored for five months at 32°, 40°, and 70° F. and planted within a few days after removal from storage.

POTATOES

The breeding work with potatoes has gone forward progressively. The thousands of seedlings that have been grown have been very rigidly selected and only those of promise saved for further test. Limited tests of the effect of heavy applications of fertilizers up to 3,000 pounds to the acre on size and shape of potato tubers have indicated no measurable modification in either respect, nor in the cooking quality; but some differences in chemical composition were found. The repeated removal of sprouts from seed potatoes resulted in a constant reduction in yield, removal the third time causing a very great reduction as compared with seed held under good seed-storage conditions.

Blackleg, not hitherto recognized as an important potato disease in the South, was partly responsible for poor stands of potatoes in the Charleston, S. C., district in the spring of 1929. It caused sets to rot and attacked young plants before emergence. Evidence was secured that the seed-corn maggot may disseminate infection, as it is already known to do in the North.

It has been shown that potatoes cut for seed and then held for a week or so at a temperature from 55° to 60° F. with a humidity of about 85 per cent form suberized tissue over the cut surfaces. Seed handled in this way, planted side by side with freshly cut seed, showed some advantages. There was apparently less danger of fertilizer injury where the cut surfaces had formed suberized tissue than where freshly cut seed was used. The suberization also offers a possibility of protection against the seed-corn maggot, which is a serious pest in some sections.

SWEETPOTATOES

Field selection of sweetpotatoes from desirable type hills of high yield which were apparently free from stem-rot infection has resulted in seed stocks which gave yields above the average as they were also above the average in freedom from disease.

In fertilizer tests with sweetpotatoes the use of potash up to 9 units per acre has shown a marked increase in yield. Neither nitrogen nor phosphorus has given any marked increase in yield. In tests of foreign varieties of sweetpotatoes several selections have been found which possess excellent characteristics and may be valuable additions to the list of commercial sweetpotato varieties.

Investigations show that the mosaic symptoms of sweetpotatoes are suppressed when the plants are exposed to a temperature of about 35° C. (95° F.). If the plants are returned to a cooler temperature, the mosaic symptoms recur in the new growth.

It has been found that wound periderm formation takes place at a temperature of 18° C. (64° F.) and above, combined with high humidity. The formation of a periderm in wounded areas in sweetpotatoes has been found to be an effective barrier to infection by the organisms causing Rhizopus soft rot, surface rot, Fusarium rot, Java black rot, and charcoal rot.

TOMATOES

Investigations carried on in California have shown that the tomato yellows disease can be considerably reduced by shading, sunflowers interplanted with tomatoes providing a convenient and effective shelter in some instances. Inasmuch as young plants are more susceptible to yellows than older ones, it is advisable to plant early, so that the plants will be well grown before the disease appears.

The mosaic disease of tomatoes has been found to live in greenhouse soils for at least 90 days, and for a shorter time in the field. As a result, greenhouse growers have been able to eliminate it in the spring crop, either by sterilization or by allowing a longer period of time to intervene between successive crops, thus allowing the virus to die out in the soil.

The new and relatively new tomato varieties, Marvel, Marvana, Marvelosa, Marglobe, Norton, Columbia, and Norduke, developed within the last few years, are highly resistant to Fusarium wilt and to nailhead rust of fruits and partly resistant to Septoria leaf spot, early blight, and leaf mold. They produce good crops of fruits on both wilt-infested and wilt-free soils, and are now commonly used by commercial growers.

The Marglobe tomato was introduced in 1925, and has proved to be well adapted to nearly all parts of the United States. Its heavy yields of good fruits, resistance to diseases, endurance of heavy rains and droughts, and quick recovery from floods and freezes in the subtropical South, have brought it into extensive use throughout the United States and western Mexico.

A new second-early, pink-fruited variety of the Marglobe type has been developed for use in regions where pink-fruited varieties are preferred. It possesses considerable resistance to most diseases and produces good crops of large, meaty, globular fruits. It looks fully as promising as the Marglobe did in the same stage of development.

PRODUCTION ON MUCK SOILS

Under the conditions in Indiana where work has been in progress for several years in a test of the plant-food requirements of the soil, the best results have usually been secured where a complete fertilizer containing moderate amounts of nitrogen and superphosphate and a high percentage of potash was used. In most cases potash appears to be the most important of the three elements, although nitrogen has occasionally given noticeable responses with leafy crops. Manure gave relatively small response, and lime definitely depressed yields. Repeated tests in the use of muck soils from Michigan, Indiana, and New Jersey, as a substitute for manure as a source of organic matter in greenhouse soils, show that such substitutions may be successfully made.

TRANSPORTATION OF PERISHABLES

The protection of fruits and other perishable products from freezing in transit during cold weather is a highly important phase of transportation. Rather extensive tests of cars standing on a siding and under actual winter transportation conditions were made. The standing test was made in Montana, where the temperature dropped as low as —40° F. It consisted of six cars of cull apples which had been donated for the purpose. The fundamentals of heater-car protection as developed by these tests showed that with a small volume of heat applied continuously in the car the lower layers of the lading can be protected from freezing and the top layers of the load will not be overheated. On the other hand, with a large volume of heat the top layers of the load will be overheated without any better protection to the layers next to the floor than is afforded by a small volume of heat properly circulated through the car. A method of stirring the air in the car by means of an electrically driven fan was developed. The methods worked out in the standing test were applied under actual transportation conditions and were found to be applicable when the cars were in motion.

A portable precooling plant consisting of two blowers, with direct-connected motors, for lowering into the bunkers of refrigerator cars, has been designed and constructed and given tests which indicate a high degree of practicability. Each unit of this precooling plant weighs about 85 pounds and the cost per unit is less than $100. The principle on which the apparatus works is to reverse the natural circulation of the air in the car, pull the air into the bottom bunker opening, and force it out of the bunker opening on top of the lading. It has been found possible with this equipment to precool a load of strawberries in five hours, reducing the field temperature of the load which ordinarily varies between 70° and 80° F. when received to an average of between 40° and 45°. In commercial tests with this equipment a difference of 5 cents per quart on strawberries has sometimes been obtained in favor of precooled as compared with nonprecooled fruit.

EFFECT OF GASES

Testing the effects on fruits and vegetables of various gases which sometimes occur in storage or in transit, or which are sometimes recommended as a means of preserving fruit in storage, was continued during the fiscal year. Carbon-monoxide gas occurs when charcoal is burned without sufficient oxygen for complete combustion. As charcoal is a fuel commonly used in heating carloads of produce in the winter to prevent freezing, it not infrequently happens that appreciable quantities of carbon-monoxide gas are developed in the cars. Tests on apples, potatoes, and other fruits and vegetables in which these products were exposed to carbon monoxide concentrations to a degree two and one-half times that which has been found in cars gave no indication of injury. The conclusion from these tests is that no danger of injury exists to these fruits and vegetables when handled in heater cars under ordinary conditions.

Laboratory, "pony" refrigerator, and car-lot studies have been made with solid carbon dioxide as a supplementary refrigerant, special attention being given to the effect of the carbon-dioxide gas upon the fruit and the fruit rots. The gas given off by the solid carbon dioxide has been found capable of causing practically complete inhibition of both the development of rots and the softening of the fruit almost immediately upon the closing of the car or other container. There is a limit, however, to the period of exposure that the fruit will stand; the greater the concentration of carbon dioxide the shorter the period of safe exposure. Different fruits vary greatly in their tolerance of carbon dioxide. Strawberries and peaches are very susceptible to injury, while grapes are very resistant. The first indication of injury to the fruit is a slight loss of aroma. This is followed by a definite insipidity of taste and finally by the development of distinctly disagreeable flavors.

In studies of sulphur dioxide as a preventive of transit rots, particularly those of peaches, strawberries, and grapes, the peach and the strawberry have been found very susceptible to sulphur-dioxide injury and apparently will not stand a strength of the gas that would be necessary to control the rots.

CEREALS

BARLEY

FROST RESISTANCE

Numerous barley varieties have been tested at an altitude of 7,000 feet at Obsidian, Idaho, during the last three years. Freezing temperatures are recorded on fully half of the nights from May 1 to August 31. Severe frosts occur in August and September, when the plants are approaching maturity. The varieties first tested were chosen for earliness, but this proved to be a poor basis for selection, as all were badly frozen. In the second year the varieties were selected on the basis of the natural habitat from which they came and also for earliness. The varieties from the high mountain regions of Asia and Africa gave much better results than those from other habitats. Many of them produced fair crops of grain, but only a few produced seed of high viability. These few should provide breeding material for producing new types adapted to a high altitude where frosts are frequent and a grain crop is needed.

SCAB

A severe epidemic of barley scab occurred in the Ohio Valley and part of the Great Lakes region in 1928, causing large losses in both quantity and quality of product. The barley acreage in the Ohio Valley was considerably increased in the spring of 1928 because of heavy winterkilling of fall-sown wheat. Most of the wheat had been sown after corn without the land having been plowed, which

left considerable quantities of old cornstalks on the ground. The fungous organism causing the scab of barley and wheat develops chiefly on old cornstalks and grain stubble. In four States (Ohio, Indiana, Illinois, and Wisconsin) the scab infection of barley varied from a mere trace to 100 per cent. A field survey showed a very close correlation between the severity of the scab epidemic and the quantity of cornstalk and other refuse left on the ground.

Marked differences were noted in the resistance of different barley varieties and selections to attack by scab in the breeding nursery conducted in cooperation with the Wisconsin Agricultural Experiment Station. The lowest infection recorded was 9 per cent, whereas the highest was 70 per cent. Continued breeding and selection should produce varieties much more resistant to scab than any now available.

CORN

BREEDING EXPERIMENTS

Extensive corn-breeding investigations at several cooperating experiment stations have given impressive evidence of the value of the new methods being used. Many strains developed in the various cooperative breeding programs yielded from 10 to 50 per cent more than the best local varieties in experiments in Virginia, South Carolina, Kansas, Nebraska, Iowa, and Ohio. Four strains, which were developed in the breeding program, carried on cooperatively with the Iowa Agricultural Experiment Station and entered in the Iowa yield test produced 10, 9.7, 1, and 7.8 bushels per acre more than the best of the open-pollinated varieties in the northern, north-central, south-central, and southern sections, respectively. In cooperative experiments with the Ohio Agricultural Experiment Station marked differences were found in the ability of strains of corn to respond to fertilizer applications. Two crosses were grown both without fertilizer and with an application of 16 tons of manure and 800 pounds of commercial fertilizer per acre. The first yielded 36.3 bushels without and 49.6 bushels with fertilizer, a difference of only 13.3 bushels, whereas the second yielded 43.9 bushels without and 70.7 bushels with fertilizer, a difference of 26.8 bushels, or twice the increase of the first.

EUROPEAN CORN BORER

In cooperation with the entomologists and agronomists of the Ohio Agricultural Experiment Station, extensive studies were made of the numbers of egg masses deposited by corn-borer moths, and the resulting final infestation, in corn of different kinds and under different treatments. The results indicate that the heavier infestation of quick-maturing sorts does not reflect their greater attractiveness during oviposition, but rather reflects a larger percentage of larval establishment from an actually smaller number of egg masses per plant. These facts provide an important clue for further study of the causes of differential infestation by the corn borer.

COLD RESISTANCE

Experiments conducted in cooperation with Funk Bros. Seed Co. and the Illinois Agricultural Experiment Station, using a portable field refrigeration chamber in which temperatures can be automatically controlled, have shown that certain inbred strains of corn and their hybrids are highly sensitive to temperatures above the freezing point as they approach maturity. Other strains and hybrids are uninjured by such temperatures. Some strains are able to resist temperatures even slightly below the freezing point. These experiments verify field observations. It also has been found that corn tissues injured by frost are unusually susceptible to such fungi as *Diplodia zeae* and *Basisporium gallarum*. Seed matured on the corn plants high in cold resistance produced plants much more resistant to seedling blights, lodging, and stalk breaking than did corresponding seed from plants injured by cold.

NATURE OF DISEASE RESISTANCE

Research on the nature of resistance in seedlings of inbred lines of corn to the attacks of root-rot and stalk-rot fungi has shown that resistance is the result of structural differences largely brought about by the conditions under which the corn seedlings are grown. Resistance may reside in the cell walls and protoplasm of the epidermis and in the thin-walled cortical cells, or it may be confined largely to the endodermis and pericycle, or it may combine both types. A physiological and chemical study of cell-wall

maturation shows that in the resistant strains cell walls are largely cellulose, with the infiltered suberoligno materials in the walls and cementing substances between the walls, while in the susceptible strains the cell walls consist largely of hydrated cellulose combined with pectinlike substances and xylan, the middle lamellas consisting largely of pectin. The chemical composition of the walls and the availability of nutritional materials, especially hydrated pentosans and easily available nitrogen, which serve for the nutrition of the invading fungus, are largely responsible for the growth.

SEED FLAX

The moisture content of flaxseed is very important where the crop is to be harvested by the combined harvester-thresher. Studies show that flaxseeds dry very rapidly during the ripening process. The ripe bolls and seeds take up moisture rapidly, however, from rain or dew or from an atmosphere of high humidity. The fitness of flax for harvesting, therefore, depends on weather conditions. The boll itself is a good criterion of the moisture content of the seeds. When flax is dry enough to harvest, the bolls open slightly at the apex and the segments separate slightly along their margins. When the bolls are wet again by light rain or dew they close tightly. Apparently the opening of the bolls occurs when the seeds contain about 9 or 10 per cent of moisture. As flaxseed is safe for storage when it contains 10 to 11 per cent of moisture, this dehiscence of the bolls is of practical importance as an indicator that the crop is ready for combine harvesting.

OATS

IMPROVED VARIETIES

It is estimated that the six improved varieties of oats, Cornellian, Ithacan, Upright, Empire, Comewell, and Standwell, developed in cooperation with the Cornell University Agricultural Experiment Station, together with the introduced variety, Victory, distributed from the same experiments, now occupy 500,000 of the 1,000,000 acres of oats grown in New York. The growing of these varieties is estimated to have increased the total oat production in New York by 2,500,000 bushels annually.

Kanota, the named strain of Fulghum, developed in cooperation with the Kansas Agricultural Experiment Station, continues to lead in Kansas and also is showing outstanding merit in California. It has been distributed to farmers in the latter State and is becoming commercially important both as a feed oat and as a milling oat.

The Lee and Custis varieties, developed at the Arlington Experiment Farm, are increasing the acreage of winter oats in southern Maryland.

FATUOID OR FALSE WILD OATS

The fatuoid forms of oats (false wild oats) appear commonly as mixtures in pure-line progenies of different oat varieties even when grown under very careful methods. Many fields offered for certification by careful growers of certified seed contain considerable percentages of such mixtures. These constitute a very serious problem both for breeders and for seed growers. Studies on the origin of such forms, therefore, are of great practical importance. Fatuoid forms have been observed in many commercial varieties, and it seems probable that no variety is entirely free from them. It has been suggested that they arise through field crossing between cultivated oats and the wild *Avena fatua*.

SMUT

Oats in the flowering stage were inoculated with covered smut at Aberdeen, Idaho, in July, 1928. The seeds from these plants were sown in the greenhouse at the Arlington Experiment Farm in December. The resulting crop contained 49 per cent of smutted plants. Seeds from the same lot stored in a saturated atmosphere for five days before sowing produced 100 per cent of smutted plants. Similar results were obtained with oats inoculated with loose smut. Apparently the conditions under which seed is stored have an important effect on the occurrence of smut in the resulting crop, a factor heretofore unrecognized.

The importance of the oat hull in preventing infection by the loose and the covered smuts of oats differs with different varieties. In general, however, any variety is more susceptible to both smuts if the hulls are removed from the seeds.

RICE

Of the varieties of rice tested in Missouri during the past year, the Japanese varieties are the most promising.

In experiments conducted in California, yields from rice sown on the surface of the soil and immediately submerged and those from rice sown in the water were practically the same. The rice submerged 6 inches produced the highest yields in both cases, approximately 500 pounds per acre more than the rice submerged 4 inches or 8 inches. Ammonium sulphate continued to give favorable results in increasing California yields, being particularly advantageous for the earlier variety, Colusa. For the standard variety, Caloro, the 4-year average increased yields from the use of ammonium sulphate, applied at rates of 100, 150, and 200 pounds per acre, were 535, 857, and 905 pounds, respectively. For the earlier variety, Colusa, the 2-year average increases from the same applications of ammonium sulphate were 728, 993, and 1,412 pounds, respectively.

GRAIN SORGHUMS

ATLAS SORGO

Atlas sorgo is a new white-seeded, stiff-stalked, dual-purpose sorghum, valuable for both forage and grain. Developed in cooperative experiments from a cross between Blackhull kafir and Sourless sorgo, it was first distributed by the Kansas station in 1928. The white seeds are classed as kafir on the market. They lack the bitter seed coat of other sorgo varieties and therefore are readily eaten by stock. The new variety is not especially drought resistant but yields well in central and southeastern Kansas. It lodges less than other sorgos and usually can be harvested with less labor.

PHYSIOLOGICAL STUDIES OF STALK JUICES

Studies conducted at Sacaton, Ariz., show that the stalk juices of durra, feterita, and milo have a higher electrical conductivity than do the juices of most other sorghums. These sorghums are typical of those grown in the highly saline soils of northern Africa and southwest Asia. The juices from the main stalks show a considerably higher concentration than those from the less mature suckers and branches of the same plants. The cell-sap concentration of the roots and crowns of sorghums is higher than that of corn. This may account in part for the greater drought resistance of the sorghums.

NEW DISEASE

Bacterial streak, a new disease of sorghums, attacks not only the grain and forage sorghums but also such hay sorghums as Johnson grass and Sudan grass. The disease occurs extensively in Kansas and is found also in Texas and Montana. A yellow bacterial organism isolated from natural lesions produces the disease when artificially inoculated into sorghum plants. The organism is being described as a new species.

WHEAT

BREEDING AND SELECTION

Newturk is an awnless hard red winter wheat developed in the bureau's breeding program. It has been widely tested for adaptation in the western United States. In cooperative tests in Montana it has been found equal to Kharkof and Karmont, standard hard red winter varieties, in yield, winter hardiness, and quality. There is a continuing demand for an awnless winter wheat in the western area. This variety meets that need and has been distributed for commercial growing in Montana. Between 8,000 and 10,000 acres were sown in the fall of 1928.

From a cross of Hussar wheat, completely resistant to bunt (stinking smut), with Hard Federation, which produces 70 to 90 per cent of bunted plants from the same inoculum, strains have been isolated which breed true for a bunt infection of only 1 to 10 per cent. This is considered proof of the existence of modifying factors for bunt resistance, additional to the main dominant factor proved common to Martin and Hussar and the second factor proved for Hussar.

COMBINE HARVESTING IN THE EAST

Continued studies show that the combine can be used successfully in harvesting wheat in the humid Eastern States. When ready to be cut with the binder wheat has a moisture content varying from 20 to 40 per cent. This moisture content drops rapidly under proper drying conditions, either when the grain is standing in the field or when bound and shocked. When the wheat is ready to be harvested with the combine, or when it is ready

to be threshed from the shock, the moisture content will be about the same, viz, 13 to 14 per cent.

In ordinary weather without rains wheat will be ready for combining in 7 to 10 days after it can be cut with the binder. The moisture content of the grain may vary as much as 3 per cent from day to night, even where there is no dew. When dew occurs, variations of 3 to 6 per cent may be expected. When heavy rains occur the moisture content of the standing grain may increase as much as 20 per cent. Standing grain, however, dries much more readily after rain than does grain in the shock. Rain on standing grain swells the kernels and decreases the test weight per bushel, often by several pounds, the decrease being in proportion to the amount of water taken up. The test weight increases again on subsequent drying, but is never as great as the original weight.

Green weeds often cause considerable trouble by raising the moisture content of combined wheat. This trouble may be largely overcome by cutting the grain with a windrowing or swathing device. After being allowed to dry in the windrow, it is threshed with the combine equipped with a pick-up attachment. The windrower is a valuable implement where green weeds are numerous, but is of little apparent advantage in weed-free fields, because grain dries almost as rapidly when standing as when in the windrow.

STEM RUST

There was no widespread epidemic of stem rust of wheat in 1928, but the evidence shows that such limited local and regional epidemics as developed in 1928 were produced from barberry infections.

In the cooperative campaign for the eradication of the common barberry for the prevention of stem rust of wheat, a larger percentage of barberry bushes and seedlings was killed with salt and kerosene in 1928 than ever before. Although other chemicals were tested for this purpose during the year, none were found to be as effective, cheap, and easy to obtain and apply as these two. Over 300 tons of salt and 1,187 gallons of kerosene were used to destroy 1,477,413 original bushes, sprouting bushes, and seedlings on 869 properties, whereas only 18,143 original bushes, sprouting bushes, and seedlings were dug or pulled from 277 properties. The total number eradicated by all methods during the year was 1,495,556 original bushes, sprouting bushes, and seedlings.

One of the principal difficulties in complete eradication is the finding and destroying of the escaped bushes that have grown from scattered seeds. Seeds from thousands of old fruiting bushes have been scattered to adjacent properties, so that there now are numerous areas in which escaped barberries and seedlings are growing under conditions that make complete eradication extremely difficult.

During 1928 a definite attempt was made to eradicate all of the bushes and seedlings from some of the larger areas of escaped barberries so that further seed spread in those areas will not be possible. Foot-by-foot surveys were extended at least 2 miles beyond the limits of the last escaped fruiting bush found, in order to insure the finding of the outer edges of the area. By this method of preventing bushes from fruiting, the further spread of barberries is being prevented. By additional surveys at 5-year intervals all of the bushes produced from seeds now lying in the ground eventually will be destroyed, and the areas will be cleared of bushes. During the year a grand total of 1,489,014 escaped bushes and seedlings were destroyed. This is more than 99 per cent of the total number of bushes destroyed during the year. The figures show the very great proportional importance of the escaped-bush problem.

To insure greater survey efficiency the system of survey has been modified. The size of the field squad has been increased from four to six men, one of whom is the squad leader. He is in immediate charge of his squad and is directly responsible for its methods of contact, thoroughness of survey, and completeness of eradication. The squad leader does not work in line with his men, as heretofore, but follows the squad and continually checks the efficiency of each man as well as of the squad as a unit.

FOOT ROTS

Results of experiments in cooperation with the Kansas Agricultural Experiment Station indicate that *Ophiobolus graminis*, the fungus causing the take-all foot rot of wheat, is able to live through the dry summers of Kansas in any layer of soil from the surface to a depth of at least 10 inches. Distinct progress was made in developing control methods for this disease. Greenhouse experiments showed a marked reduction in the amount of infection occurring in soils

where the disease was known to be present, when certain organic materials were added to the soil. The addition of chicken manure gave 97 per cent control; ground barley and oats, 88 per cent control; potato flour, 88 per cent control; and alfalfa organic material, 65 per cent control. Adding sodium nitrate to the soil reduced infection only 5 per cent. In field experiments the application of barnyard manure to take-all-infested spots reduced infection 50 to 75 per cent.

The Helminthosporium foot rot of winter wheat caused considerable loss in Montana and Colorado. Some fields were left unharvested because of the disease. The estimated loss was 100,000 bushels in the Judith Basin of Montana and 175,000 bushels in Weld County, Colo. The disease was most destructive in fields sown earlier than the customary date. It is known that the Helminthosporium causing this disease is most destructive at relatively high soil temperatures, and it is recommended that sowing dates be as late as compatible with obtaining maximum yields. At Moccasin, Mont., on infested soils, strains of Eureka × Turkey, Kanred × Minhardi, Kawvale, Kanred × Beloglina-Buffum, and Menno were found to possess considerable resistance to the disease.

A foot rot of wheat caused by an undetermined species of Fusarium occurred in 1928 in western Kansas, eastern Colorado, and Oklahoma. The organism causing the disease was isolated from diseased plants repeatedly, and its pathogenicity was proved in greenhouse inoculation experiments. Fortunately, this trouble was found to occur in most cases only on farms where poor practices had been followed.

A destructive foot rot of wheat also occurred in the Columbia Basin counties of Oregon and Washington in 1928. The estimated loss was fully 100,000 bushels. A survey of the affected area was made, and attempts are being made to isolate the causal organism from diseased plants. As yet the cause of this trouble is undetermined.

MOSAIC DISEASE

Wheat mosaic recently has been found to occur to a limited extent in Davidson County, N. C. The disease now has been reported from six counties in Illinois, three in Indiana, one in Virginia, and one in North Carolina. A somewhat similar mosaic also has been found in one county in Maryland.

The mosaic disease of wheat may cause rosette on a limited number of varieties of winter wheat. There are two types of the mosaic leaf mottling, the yellow and the green, which occur on susceptible varieties whether they show the rosette phase or not. The yellow types of mosaic are very destructive. Plants infected with this type frequently are stunted and produce only a few shrunken seeds. This is important because this type of infection can not be detected early enough in the spring to permit reseeding to other crops. A mosaic-infested field near Granite City, Ill., was accidently sown to a susceptible wheat variety in the fall of 1928. The crop was badly infected with mosaic, showing that the virus of wheat mosaic remains in the infested soil in a virulent condition for a considerable period of years.

SMUTS

Studies cooperative with the Oregon and Washington stations show the existence of physiologic forms of both stinking smuts, *Tilletia tritici* and *T. laevis*. Decided differences in the pathogenicity of the different forms were found. The varieties Hope, Hohenheimer, Alaska, and Ridit showed a high degree of resistance to all forms tried in these experiments and offer a most encouraging basis for future operations in breeding for smut resistance. Ridit, developed at the Washington station, already is in commercial production. It was responsible for a considerable part of the reduction in Pacific Northwest terminal receipts of smutty wheat noted in 1928.

Carefully conducted hand-inoculation experiments with Hope wheat have failed to produce any loose smut in this variety. Hope possesses a high degree of resistance to stem and leaf rusts and to stinking and loose smuts and is the most promising parent now available for breeding disease-resistant wheats.

The flowers of wheat plants grown under dry-land and irrigated conditions in cooperative experiments at Aberdeen, Idaho, were inoculated with loose smut in 1928. The seeds from the dry-land crop produced 14 per cent of smutted heads, while those from the irrigated crop produced 68 per cent of smutted heads. Similar results were obtained from an experiment conducted at Moro, Oreg. Low relative humidities apparently explain the absence of loose smut in susceptible varieties when grown in the dry-land areas of the West.

FORAGE CROPS

ALFALFA

COMPARISON OF SEED FROM VARIOUS SOURCES

The demand for information regarding the adaptability of alfalfa seed from various sources has been greater than ever before and has necessitated increased attention to this phase of alfalfa investigations. New tests were therefore started in cooperation with agricultural experiment stations in the East and in the Corn Belt, and the work was enlarged at stations where work was already under way. The results of the past year's work bear out the previous tests in showing that none of the imported alfalfas are superior to some of our domestic strains for any part of the United States with the possible exception of those districts where bacterial wilt is prevalent. Most of the seed from foreign sources, however, is fairly satisfactory when sown in those limited areas to which the seed is adapted. Argentine alfalfa has given good results in the South, though seldom equaling the best domestic strains in yield. The use of seed from that source in the North ordinarily results in serious losses through winter killing. Recently considerable interest has developed in Turkestan alfalfa in the Middle West, because of the apparent resistance of certain strains from that source to the bacterial wilt. This statement, however, must be accepted with some reserve for the present, for the evidence is by no means complete. The importance of the wilt problem and the observational evidence from old fields warrant a continuance of this line of work, and further studies are under way to determine definitely the resistance of this strain to bacterial wilt.

Additional tests bear out previous findings in that certain strains of Turkestan alfalfa have given fairly satisfactory results in the northern Great Plains, though seldom equaling in yield such varieties as Grimm and Cossack. Turkestan has again proved decidedly inferior to domestic alfalfas in the South and in the eastern humid districts. In the Northern States where winterkilling is a serious factor there are no alfalfas superior to such varieties as Grimm and Cossack. Ontario Variegated alfalfa, although somewhat less resistant to cold than Grimm and Cossack, is still a fairly dependable variety for most northern districts, and the seed has been comparatively cheap. Unfortunately, conditions were unfavorable to alfalfa seed development in Canada in the season of 1928, so that growers who have heretofore depended upon this variety have been compelled to seek seed from other sources. Ladak alfalfa has again proved its superiority in yield and hardiness in several tests in the northern Great Plains and under irrigation in the intermountain country. It has proved decidedly inferior to Grimm and Ontario Variegated in the northern humid districts.

Of the domestic strains of common alfalfa, none has proved superior for the North to those from the Dakotas and Montana. Utah seed, of which there is a large quantity, has not proved so cold resistant as Dakota Common. It seems to be adapted to about the same climatic conditions as Kansas Common. New Mexico Common in general proved a little less hardy than Utah Common. Arizona Common is the most susceptible to cold of any of the common domestic strains. There has been a considerable overproduction in Arizona, and, unfortunately, much of the seed has been marketed in the North, where its use has resulted in serious losses. Several cases have come to the attention of the department where Arizona seed has been mixed with northern seed, a practice which also results in losses.

BACTERIAL WILT

During the season of 1928 losses of 30 to 50 per cent of the alfalfa in some of the best alfalfa-growing districts, from the spread of the bacterial wilt, were reported. This disease has attracted the serious attention of alfalfa growers in the Middle West, especially in Kansas, Nebraska, and Colorado, where the losses have been unusually heavy. Chief attention is being given to the selection or breeding of a disease-resistant strain, as this seems the most hopeful line of endeavor. Thus far it appears that the Ladak variety and certain strains from Turkestan and from Provence, France, possess some resistance to the disease. The relation of winter injury to the wilt is being thoroughly investigated, as it appears that the two are closely associated.

RED CLOVER

Since the passage of the seed-staining amendment to the Federal seed act, samples representing most of the lots of red clover imported have been

subjected to field tests. The records show that the red-clover seed imported into this country during recent years gives results far below those obtained from the use of domestic seed. It is evident that a larger production of domestic seed is necessary. With a view toward encouraging production in favorable parts of the intermountain States, a survey was made and arrangements completed for trials by 36 selected farmers in 22 counties of 5 States. While favorable conditions of climate and soil were naturally taken into account, the economic factors were also studied and an effort was made to establish trials in sections so far removed from the railway as to make the hauling of hay or grain difficult or impossible. Clover seed having a high unit value can be hauled longer distances. The establishment of a clover-seed-growing industry should, therefore, be of benefit to the residents of these intermountain States as well as to the eastern consumer of red-clover seed.

The presence of an anthracnose disease of red clover in the southern part of the Clover Belt renders the use of a strain resistant to this disease very desirable. More satisfactory seed yields are obtained in the West than in the East; however, it was not known whether a strain resistant to the disease in Tennessee would retain its resistance if grown in the West where the disease in question does not occur. Trials made have shown that the Tennessee anthracnose-resistant strain can be grown for at least one generation in Oregon and Idaho and retain its resistant character. Trials are now under way to determine how long this strain can be grown in the West without renewal of stock.

SWEETCLOVER

The rapid extension of sweetclover culture to all parts of the country has created a demand for varieties or strains of this crop adapted to widely diverse conditions. To meet the demand, types of sweetclover have been obtained by selection and by importation and tested at experiment stations. By this means varieties have been developed that are resistant to drought and to cold, as well as early and late varieties for special uses. This year for the first time sufficient seed of some of these varieties was available to permit of a limited distribution.

A serious obstacle to the culture of sweetclover has been the uncertainty of obtaining a stand. After many years of experimentation methods have been devised that greatly increase the reliability of the seeding. Essentially the process consists of very early seeding of unhulled or unscarified seed on a hard seed bed.

SOYBEANS

While no doubt the acreage in soybeans for hay will constantly increase, the largest field for soybeans will evidently be for oil and concentrated-feed production. The cake left after oil is expressed is a concentrate of high protein value. The oil and protein content both vary with the variety, but not necessarily in the same direction. A study of the oil and protein content has therefore been begun in cooperation with the Ohio Agricultural Experiment Station. The oil and protein content of hundreds of selections will be determined, with a view to selecting specifically for those qualities.

During the last three years some 3,000 to 4,000 individual selections of soybeans have been made from the bureau breeding plots, and several of these, such as Mansoy, Harbinsoy, Delsoy, and Old Dominion, have shown great promise and are now being used in the Corn Belt and in the Southeastern States. In the future efforts will be concentrated on breeding for oil and protein. Two objectives will be kept in view, namely, breeding for high oil and protein content so as to get a more valuable bean for industry, and breeding for low oil content to get a better bean for hogging off.

Meanwhile a specialist has been sent to Japan and China to study the methods of oil production and to procure seed of promising new varieties. Already about 2,000 introductions of soybeans have been made, representing some 500 distinct varieties. The soybean has been found variable in its adaptation to local conditions, so that it is necessary to introduce as many varieties as possible in the hope that some will fit into conditions in this country for which at present no variety is wholly satisfactory.

TIMOTHY

Besides the continuance of the selection work for the production of improved varieties of timothy, certain cultural studies are being carried on. It has been found that seeding timothy in the fall at a rate of 5 or more pounds per acre and clover in the spring resulted in lower hay yields and in a smaller proportion of clover in

the hay than when the same quantity of timothy was seeded in the spring. When both timothy and clover were spring seeded the total yield of hay declined as the rate of seeding increased. The best practice was found to be to seed timothy in the fall at not over 2.5 pounds per acre and to seed the remainder in the spring with the clover.

NEW VARIETIES OF LESPEDEZA

Korean and Kobe lespedeza, the former from Korea, the latter from Japan, have still further demonstrated their value. Introduced by the Department of Agriculture in 1923, when some 200 pounds of seed was distributed, the Korean lespedeza has spread, and the demand for seed has increased so that the total sale of this variety during the season of 1928 was more than 150,000 pounds. This variety has been found especially valuable for seeding on grain for grazing after the grain is harvested. At high altitudes where common lespedeza does not reseed the Korean can maintain itself.

PASTURE STUDIES IN THE SOUTH

CULTIVATED GRASSES FOR GRAZING

For some time studies have been under way in cooperation with the Florida Agricultural Experiment Station at Gainesville to determine whether certain cultivated grasses can be profitably grown on the sandy cutover lands of that section. In 1928 these areas were grazed with piney wood steers in poor condition, and careful record was kept of costs and returns. The seven steers, grazing on 7 acres, gained an average of 1.24 pounds per day and made a profit above labor and fertilizer costs of $7.82 per acre or per steer. It was shown that a properly conducted pasture of cultivated southern grasses would carry one animal per acre, and this is as much as could be expected of a good bluegrass pasture in the North.

EFFECT OF NITROGENOUS FERTILIZER

In another experiment at Gainesville, Fla., it was found that turf-forming grasses respond markedly to nitrogenous fertilizers. Light applications of sulphate of ammonia were made to Bahia grass, centipede grass, and carpet grass, and the yields and protein content were determined. An application of 250 pounds of sulphate of ammonia per acre increased the yield of Bahia grass 52.9 per cent, that of centipede grass 82.2 per cent, and that of carpet grass 89.7 per cent. There was also an increase in the protein content of Bahia grass and of centipede grass, but the fertilizer had no effect on the quality of the carpet grass.

ENFORCEMENT OF THE FEDERAL SEED ACT

During the fiscal year there were imported into the United States 35,880,300 pounds of seed subject to the Federal seed act, this quantity being approximately 80 per cent of the average annual importations during the last seven years.

In the enforcement of the Federal seed act every shipment is sampled by the United States Customs Service, and all of the samples are examined by the seed laboratory of the Bureau of Plant Industry before notice of permission or rejection is issued to the Customs Service.

The Federal seed act requires the coloring in varying proportions, according to the country of origin, of all seed of alfalfa and red clover permitted entry into the United States. During the fiscal year this coloring was supervised by representatives of the seed laboratory. The coloring of nearly 9,000,000 pounds of seed was involved.

Under the interstate clause (sec. 6) of the Federal seed act many cases of shipments in interstate commerce of misbranded seed have been reported to the department for investigation. These have included the branding with respect to germination, variety, and origin of seeds of alfalfa, rye, soybeans, and red clover. In a number of cases the seed was recalled by the shipper, and in other cases where seizures were made the cases were settled by the court's releasing the seed to the shipper under bond that it would be disposed of in accordance with Federal and State laws. In every case of misbranding which has been reported to the department the shipper has admitted misbranding, and no case thus far has gone to trial.

The seed laboratory in Washington cooperates with the States in maintaining branch laboratories in California, Missouri, Indiana, and Oregon. At all of these laboratories samples of agricultural seeds are tested for farmers and seedsmen, and they serve as control laboratories in connection

with the enforcement of the Federal seed act. Both in the United States and in Europe germination tests under artificial laboratory conditions have been interpreted to show a percentage of germination higher than the possible plant-producing power of the seed, even under the most favorable conditions. This is particularly important with samples containing large proportions of weak seeds. The discussions at the last meeting of the International Seed Testing Association, as well as recent publications, have emphasized the importance of so evaluating germination tests as to express the potential value of the seeds for plant production. It is coming to be generally recognized that satisfactory rules governing the testing of seeds passing in foreign commerce can not be formulated until there is a common appreciation among those responsible for the direction of Government seed-testing laboratories that the practical relation of seed testing to agriculture is based on the potential plant-producing power of the seed.

SUGAR PLANTS

BEETS

CULTURAL EXPERIMENTS

The production of sugar-beet seed from stecklings overwintered in the field has continued in New Mexico with promising results. A commercial planting by the new method on one-fourth acre in 1928 produced a yield of 3,400 pounds of clean, marketable seed per acre. Experimental results further indicate that highest seed yields are obtained from plantings where no thinning whatever is done. The highest yields in 1928 were from plantings with an ordinary grain drill, with no subsequent cultivation or thinning. Lessened viability of seed produced in previous years seems to have been overcome by frequent heavy irrigations during the blooming period. There is reason to believe that sugar-beet seed can be produced by this method at a cost not to exceed 5 cents a pound, a marked saving as compared with the expensive method of siloing the stecklings in the fall and replanting laboriously by hand in the spring, which is the practice made necessary by climatic conditions in Europe and followed heretofore in the United States.

In experiments on the treatment of sugar-beet seed, dusts containing mercury have been found most effective in giving satisfactory initial stands of seedlings in experiments carried on in Washington and at field stations. In areas where rainfall conditions make seedling damping-off serious, seed treatment furnishes protection to the growing plant not alone from seed-borne parasites but from the parasitic soil fungi. Since in the humid areas and in certain western areas loss of seedlings from damping-off, and the resultant poor stand, have been potent factors in low yields of sugar beets, the protection of the seedling by the application of a fungicide to the seed ball offers a ready means of relief from injury of this type.

In cooperative investigations carried on with the Bureau of Chemistry and Soils, five years of tests to determine the best fertilizer practice for each of the great agricultural sections where beets are an important crop have been completed. In many areas marked gains in yield have been obtained by proper fertilizer applications, and in general a balanced fertilizer with high phosphorus content seems more effective with the soils of Michigan, Montana, Iowa, and Colorado. In Utah, applications of manure have given better results than the chemical fertilizers, and the situation there as well as in the other States is still under investigation. Fertilizer applications commonly have been made along with the seed, but tests at the Colorado field station indicate that side dressings given throughout the season may have some advantage with soils deficient in fertility.

DISEASES

The work on curly top of sugar beets has been mainly devoted to development of resistant varieties. The outstanding development during this period has been the establishment of the fact that resistance to curly top is not necessarily associated with low sugar content. Extensive tests demonstrated that some varieties of beets sufficiently resistant to give good yields in spite of curly top are also satisfactory from the standpoint of sugar content.

In connection with resistance studies, the interesting fact has been brought out that the curly-top virus is attenuated by passage through strains of beets that are symptomless carriers. Further work along this line has yielded evidence that the attenuated virus may be reactivated to a virulent state.

The retarding effect of curly top on size of sugar beets and the subsequent

inefficient utilization of the soil space have been shown by agronomic investigations in Utah and Idaho to be partly compensated by changes in cultural practices, notably by closer spacing of plants to give a greater number of individuals to the acre. Another field practice which has been found effective in minimizing losses from curly top is taking advantage of the fact that injury by curly top is curtailed when the plants have reached considerable size at the time of infection. Sugar-beet seedlings beyond the 6-leaf stage have been successfully transplanted by mechanical means and have given increases under curly-top conditions of over 5 tons to the acre, because of the superior stand, longer growth period, and greater capacity for withstanding infection than the beets under normal culture used as checks.

Direct control of leaf spot of sugar beets (caused by *Cercospora beticola*) by the use of fungicidal dusts and sprays has now been tested for four years in the Arkansas Valley of Colorado, and the value of these protective measures has been demonstrated under epidemic conditions. Effective and profitable control of leaf spot by dusting was obtained in a series of tests in commercial fields and the practicability of the measures shown. Increase in tonnage, sugar percentage, and purity, resulting in decided increases in net sugar per acre, were obtained in these experiments. For field application of dusts the ordinary dusting apparatus was mounted on an autotruck, and this machine was found very efficient. The operation of the machine did less injury in the fields than the horse-drawn duster, and the speed of application was greatly increased. The autoduster offers distinct advantages in cases where some central agency can furnish this service to farmers or where the fields are widely separated. Best results were obtained with a dust composed of 20 per cent monohydrated copper sulphate and 80 per cent hydrated lime.

Experiments in Utah and Washington on the effect of delayed thinning as a means of controlling seedling diseases have shown that increased stands may be obtained by delaying thinning operations until the seedlings have at least six leaves. Sick seedlings are eliminated by natural means during the period of delay, and where infection in the cotyledon stage does not exceed 75 per cent the method offers a means of greatly increasing the stand of beets, which, as is well known, is one of the most essential requirements for improving the yield.

Studies on the relation of methods of topping beets at harvest and storage losses at beet dumps and factories indicate that more rot develops when the crown is severed at the base of the lowest leaf scar than when beets are topped slightly higher. Morphological differences in beet tissues in these regions appear to offer a satisfactory explanation of the results obtained. Higher topping is beneficial because with but slight increase in tare it improves the tonnage somewhat and markedly reduces sugar, rot, and shrink losses.

CANE

NEW VARIETIES

As the result of an airplane expedition in 1928 to the interior of the island of New Guinea, thought to be the original home of the so-called "noble" varieties of sugarcane, 176 varieties of cane were collected, and cuttings have been planted in the quarantine greenhouses at Washington. More than 100 of these varieties, which were selected for disease resistance, have survived the long trip to Washington and are now established and in a flourishing condition. They will be tested for adaptability to conditions in the commercial sugarcane areas as soon as they are released from quarantine.

The enthusiastic reception by planters in Louisiana of the mosaic-tolerating varieties of sugarcane introduced by the department has been well justified by the continued excellent performance of these varieties in 1928. Once the merit of these varieties was recognized, they displaced the ones formerly grown as rapidly as seed cane became available. The present year (1929) marks the end of a complete revolution in varieties that began in 1926. In that year 47,166 short tons of sugar were obtained from 127,916 acres of cane, the poorest yield in half a century. In 1927, with only one-fourth of the total acreage planted to the new varieties, 70,792 tons of sugar were obtained from 72,987 acres planted. With nearly three-fourths of the acreage planted to the new canes in 1928, 171,000 tons of sugar were manufactured from 144,500 acres used for sugar production out of a total planting of 179,000 acres. It is estimated that more than 200,000 tons of sugar will be produced in 1929 from 173,000 acres to be harvested for milling out of a total planting of 204,000 acres.

DISEASES

Considerable advances have been made during the year on the sugarcane root disease complex, which is one of the most serious problems of sugarcane culture in Louisiana. It had previously been established that injury to the roots of sugarcane early in the season was associated with injuries caused by small animals (snails, centipedes, etc.). These injuries were believed to be predisposing causes of the root disease, and therefore in the preliminary studies attention was focused on the small animal organisms attacking the roots. Extensive root examinations in 1928 confirmed these results with respect to early season conditions. As the season advanced damage by the small soil fauna became less evident and less injurious and rotting shifted from the young fleshy roots to the fibrous roots of the rapidly expanding root systems. As in the case of mosaic, the evidence points to resistant varieties as the most rational method of control, and several promising cane varieties have been discovered to withstand attack without severe injury.

Comprehensive studies on the rate of deterioration of the sucrose content of standing cane, windrowed cane, cane cut for the mill, and stubble rhizomes of the mosaic-tolerating varieties introduced by the department were carried on during the year. The results indicate that cane cut for the mill early in the season deteriorates in about four days. Later in the season, after the cane has been frosted, the rate of deterioration is much slower and there is no loss of sucrose for the first 10 days after cutting. The cane windrowed early in the season after a light frost deteriorates in about one week, while that windrowed later after a freeze severe enough to kill the growing point keeps in good condition for about six weeks. After a severe freeze the standing cane will remain in millable condition for about three weeks. These experiments show that the P. O. J. canes now extensively planted should not be windrowed until killed by a frost, and that after a severe frost only the cane that can be milled in three weeks' time should be left standing and the remainder immediately windrowed.

DRUG PLANTS

MENTHOL FROM JAPANESE MINT

The economic situation with regard to natural menthol has undergone a distinct although perhaps not a permanent change as a result of the unusually heavy production of *Mentha arvensis* oil, from which menthol is obtained, during the last two years in Japan. Experiments in the culture of the Japanese mint were continued in various sections, especially in the South. Its commercial culture in central California has demonstrated that large yields of oil with a high menthol content are possible in that section. The milder climate prevailing there is also of distinct advantage, in view of the tendency of this mint to suffer from winter killing.

SAFFLOWER AND HEMP—NEW DRYING OILS

The drying-oil-consuming industries are dependent to a large extent on the importation of such oils to meet their requirements. An increased domestic production would be not only a distinct advantage to such industries but would be a material aid to agriculture in the regions where crops producing such oils can be introduced. Safflower and hemp are oil-seed crops adapted to the small-grain districts of the northern Plains States, and experiments in their culture have been carried forward during the year on an increasingly large scale.

About 57 acres of safflower were grown in 1928. Half of this acreage was planted by department collaborators. The yield of seed was decidedly lower than in the preceding year, on account of the late and dry spring, which delayed sowing and resulted in only a partial stand. A number of the farmers failed to follow instructions furnished them and obtained correspondingly poor results. The year's experience has demonstrated the following points: (1) The crop must be sown early to permit it to mature before frost; (2) the land should be plowed at least 8 inches deep, on account of the long taproot of the plant; (3) land too poor for flax and other small grains will not produce a good crop of safflower; (4) land that is excessively weedy is unsuitable, especially if germination of the safflower seed is delayed by drought or cold weather; (5) heavy gumbo soils produce a much lower yield than clay loam soils, both under irrigation and in dry farming; (6) on irrigated clay loam soils a yield of 50 to 60 bushels per acre is reasonably certain, but under dry-farming conditions the yield may be 20 bushels or nothing, according to seasonal conditions. Additional tests of the oil in the industries and feeding tests of the

oil cake made during the year have further emphasized the commercial possibilities of these products. The cake, although somewhat unpalatable as such, is readily eaten by cattle and hogs in mixed rations.

Approximately 150 acres were planted in 1929 by 100 farmers in 23 States. Oil-seed crushers have indicated their willingness to buy the seed produced at 90 cents to $1.50 a bushel when commercial quantities are available. The price will vary with the price paid for flaxseed.

LOSS OF CEDAR OIL FROM CEDAR LUMBER

The practice of lining clothes chests with cedar veneer instead of constructing them entirely of cedar lumber led to a study of the relative loss of cedar aroma from cedar wood of various thicknesses. The experiments demonstrated that cedar boards less than half an inch thick soon lose their efficacy against clothes moths to such an extent that their use in the construction of cedar chests should be discouraged. As a result the manufacturers have largely discontinued the use of thin cedar veneer in the manufacture of these chests.

ORNAMENTAL PLANTS

BULBS

The main features of the work the past year, as heretofore, have been with bulbs of primary commercial importance, including the tulip, hyacinth, daffodil, and various lilies, but in addition, a number of genera represented by perhaps a hundred different varieties of miscellaneous bulbous stocks which are under experiment.

The questions under consideration concern cultural requirements, methods of curing, handling, and storing the bulbs, time of planting, practices that are effective and economical under American labor conditions and other conditions, regions where the different kinds of bulbs can be grown to advantage, and the modification of methods and practices in one region to correspond with those in another, in order to best promote the objective of the work, namely, the establishment of an American bulb industry.

TULIPS

The conclusion that tulip breaking is an infectious mosaic disease has been confirmed. Rembrandt tulips of commerce are mosaic-infected. Bizarre and Bybloemen tulips appear to be mosaic-diseased Breeder and Old Dutch types. To date the evidence is that tulips are affected by only one mosaic disease. Three species of aphids have been found to transmit infection in experiments. When aphids are numerous, natural spread may be rapid. Proper segregation from mosaic-infected plantings and roguing of diseased individuals reduce or eliminate this disease.

Tulip fire was unusually destructive in the Northwest in 1928. The casual fungus may overwinter in the soil, and is also carried on planting stock. Tests of a number of fungicides for the disinfection of planting stock and of sprays and dusts to control secondary foliage infections have not yet developed practices that can be unqualifiedly recommended. On the other hand, selection of clean planting stock and roguing of plants with primary infections, while the best controls yet known, do not invariably effect complete control.

DAFFODILS (NARCISSUS)

An outstanding accomplishment during the year is the determination and analyses of a number of daffodil reactions. These have to do mainly with blemishes caused by a Tarsonemus mite and its control. This mite is capable of reducing yields and causing injury to stocks in forcing. The organism is controlled by the hot-water treatment. To maintain stocks free of this pest it may be necessary to apply this treatment every three or four years indefinitely. Recently imported stocks are free of evidences of infestation, because they are given this treatment before they are shipped and upon entry into this country. This mite is apparently less injurious in warm climates. The reactions of daffodils to this Tarsonemus constitutes much of what has previously been referred to as mosaic troubles.

Narcissus basal rot caused the loss of at least 2,000,000 bulbs of commercial sizes in Virginia and New York in 1928. A particular species of Fusarium appears to be the cause. Infection may enter the plant through the dying root system in midsummer, particularly during periods of warm weather, and so be present in the bulbs at the time of digging. It was found that maintaining a moderately low temperature, 60° to 65° F., during curing was of greater effect than prompt drying in preventing bulb rot. Spread of basal rot may ensue from the hot-water treatment if infected bulbs are mixed with healthy ones dur-

ing the treatment. Frequent change of water, periodic heating to a temperature fatal to fungus spores, or the use of a fungicide in the water are advisable to prevent such spread. Tests indicated that several standard and proprietary fungicides may be used for this purpose without serious injury to flowering or growth.

A large percentage of the narcissus varieties, Minister Talma, Sir Watkin, Weardale Perfection, and Lucifer, are commonly affected with narcissus mosaic. King Alfred is sometimes extensively infected and the plants considerably dwarfed. Experimental proof of the infectious nature of the disease is not available, but field observations indicate definite though slow spread. Roguing is an effective control, but is not yet extensively practiced by growers.

ROSES

In the production of Manetti stocks for the propagation of forcing roses, size and kind of wood for cuttings and method of planting are controlling factors. Under certain conditions of the investigations, the best results have been obtained by planting the cuttings in triple rows, spacing them about 1 inch apart. In grafting experiments western-grown Manetti stocks have compared favorably with those imported from England and Holland. In a 3-year outdoor test of hybrid tea roses on different stocks, *Rosa multiflora* roots have produced more blossoms than those on other stocks.

TOBACCO

EFFECT OF MAGNESIAN LIMESTONE

Recent studies have demonstrated that some of the important light tobacco soils do not contain sufficient magnesium and calcium to meet the requirements of the tobacco crop. Unless these elements are supplied, tobacco develops definite pathological symptoms, and both yield and quality are lowered. Where both elements are deficient the addition of magnesium alone even in comparatively small quantities may result in serious toxic effects. If calcium in suitable proportions accompanies the magnesium, however, no toxic action results, even when heavy applications are made. It has been found, in fact, that the tobacco plant will grow normally in pure dolomitic limestone which has been crushed, if a nutrient solution is applied. Hence, no toxic effect is to be expected when magnesian limestones are applied to the soil for the purpose of supplying magnesium or calcium or for correcting excessive acidity. The quantity of such limestone that may be safely used depends not on the danger of toxic effects but on that of unduly reducing soil acidity, thereby favoring development of root diseases.

EFFECT OF CHLORINE

It has been demonstrated that on some soils fertilizers supplying moderate quantities of chlorine produce an appreciable increase in yield of tobacco. The size of the leaf is increased, and after curing the color, elasticity, and other elements of quality are improved. On the other hand, the use of too much chlorine is decidedly injurious to growth, resulting in an abnormally thickened leaf, and after curing the product possesses undesirable colors, unsatisfactory combustibility, and poor keeping qualities. Physiological studies have shown that chlorides have a decided effect in increasing the water content of the leaf and may be quite effective in preventing injury from the so-called "drought spot," which is essentially a localized drying out of the leaf tissues. Moreover, the increased water content resulting from the presence of chlorides in the tissues may profoundly affect carbohydrate metabolism. A high content of chlorides thus tends to paralyze the enzymatic processes involved in transformation of starch into sugar, thereby impairing the nutrition of the plant. By properly controlling the chlorine content of the fertilizer it is possible to secure its beneficial effects and at the same time avoid the injurious action on the nutrition of the plant and the quality of the cured leaf.

FIBER PLANTS

COTTON

SELECTION TO MAINTAIN ADAPTATION

Improved methods of selection are being developed, to give better assurances of maintaining the uniformity and productiveness of superior varieties of cotton, and also of preserving the adaptive characters that render it possible for some varieties to produce good crops under a wide range of conditions. Selection for these purposes is based on the recognition of a single superior type and is restricted to individuals of this type which are superior to their neighbors in vigor and productiveness. Also the experiments indicate that work of selection with a

superior variety should not be limited to a single locality or district, but preferably should include the entire range of conditions to which the variety is adapted. The need of such precautions is shown by the fact that strains of the same variety which have appeared to be of equal value and productiveness in some of the tests have behaved quite differently under other conditions. Some of the strains showed their ability to continue growth and fruiting under conditions that resulted in definite checking of other strains, leaving no doubt that differences of adaptation existed, although they had not been detected in the localities with the more favorable conditions.

The superiority of the Acala cotton over other upland varieties has been shown in a series of carefully conducted tests in California in the season of 1928. Special precautions are necessary to make reliable tests of varieties of cotton in the irrigated valleys, on account of the very wide range of temperature and moisture conditions and the generally uneven character of the soil. To make the comparisons as definite as possible, each test is limited to two varieties, which are planted in alternating strips; the strips are cut at picking time into short sections, and the rows of each section are picked and recorded separately. By this method the effects of irregular conditions are clearly shown and numerous direct comparisons between the two varieties are afforded. Several such comparisons of Acala were made with the Lone Star, Mebane, and Delfos varieties, and the regular stock of Acala, selected in the Coachella Valley, was compared with two other strains, which proved not to be so good for general use.

FACTORS OF EARLINESS

Several distinct factors are shown to be responsible for earliness in cotton, as a result of many tests and comparisons of the behavior of the same varieties in different regions of the Cotton Belt. Some of the earliness factors are more valuable than others, and some are not desirable but rather to be avoided in selection. The ability of the Acala cotton to make more growth in cool weather than other upland varieties is an important character of earliness, and the growth of the cotyledons to large size in the Kekchi cotton is another character that gives a practical advantage in earliness. On the other hand, very early flowering or the setting of a few bolls very early in the season may not be an advantage, since the growth of the plants may be retarded and a longer crop period required. Earlier opening of bolls may result from greater susceptibility to checking of growth by unfavorable conditions, which should not be mistaken for an ability to produce a normal early crop. The most practical form of earliness is the ability to set a good crop within a short period after fruiting begins.

FACTORS OF DIVERSITY

In the breeding of cotton varieties for uniformity of fiber, several forms or factors of diversity are found to be generally represented, which are not so readily distinguished in the commercial product. Much of the diversity in commercial cotton fiber is due to mixing and mongrelizing of the seed stocks, though even in purebred varieties only a part of the fibers are of the length that is ascribed to the commercial sample. The so-called "butterfly" varieties have only short fibers at the base of the seed, while some of the fibers at the top of the seed are much longer. Also, short fibers are found generally among the long fibers even in the varieties that are not butterfly. The short "subsstaple" fibers are readily seen in combed samples of seed cotton, as they remain attached to the seed after the longer fibers are pulled out. Other factors of diversity, affecting both the length and character of the fibers, are found in the effects of adverse conditions, which interfere with a normal development of the fibers to a greater or less extent.

DEFECTIVE BOLLS

Losses from rotting of green bolls are notably increased in some districts by defective structure of the bolls. Some varieties of cotton produce many bolls with open sutures at the tip, sometimes known as "split-nose" bolls. The sutures are seen on the outside as short grooves or furrows near the tip of the boll, midway between the lines of separation where the bolls split open at maturity. The open sutures render the bolls more susceptible to rotting and mildew and under humid conditions may occasion a serious reduction of the crop, especially where the plants grow rank and the bolls are shaded by heavy foliage. This deformity appears commonly in cluster variations and often is accompanied by proturber-

ances at the base of the bolls, which may be considered as supernumerary carpels. Thus the boll abnormalities, even when not directly injurious, are indications of unstable heredity. Though some of the abnormal characters may appear only under special conditions or late in the season, even such indications of abnormality are to be avoided in breeding and selection.

SEA-ISLAND COTTON

Experiments with sea-island cotton have been conducted for several years on James Island, near Charleston, S. C., in cooperation with the South Carolina Agricultural Society, to determine the possibility of protecting this superior type of long-staple cotton from the boll weevil. The experiments indicate that it may not be impossible to reestablish the sea-island industry if separate communities are organized to grow the sea-island cotton exclusively, since the dangers of weevil injury are greatly increased by the proximity of upland cotton, as is also the danger of mixing and mongrelizing the seed stocks. The practicability of establishing isolated sea-island cotton communities is increased by the fact that the growing of short-staple upland cotton has now been abandoned in some of the former sea-island districts. New England manufacturers of long-staple cotton recently have shown an active interest in the experiments with sea-island cotton and have contributed to the effort of establishing the supplies of seed which would make it possible to resume the production of this type of cotton not only in the vicinity of Charleston but also in some of the districts in Georgia and Florida that formerly were devoted to its production.

PIMA COTTON

It is estimated that 67,000 acres in the Salt River Valley, Ariz., have been planted to Pima cotton in 1929, the largest acreage of Pima since 1922. Nearly half of the Pima seed planted this season was of the selected strain 5–3. Every precaution has been taken in increasing this seed to protect it from contamination, and it is believed to be of exceptional purity. Further comparisons with the old Pima stock have shown no difference in productiveness and earliness, but the lint of the new strain averages about one-eighth inch longer and the yarn spun from it appears to be somewhat stronger.

Some American manufacturers of long-staple cotton prefer Sakel (Sakellaridis) cotton, the longest linted of the varieties grown extensively in Egypt, to Pima. Experiments with Sakel on the irrigated lands of Arizona and California have shown the plant to be of a less satisfactory character than Pima. The Sakel plants are much more "limby," more prone to shedding, less productive, and later maturing, and have smaller bolls than the Pima plants. In Egypt, also, where Pima cotton is now being grown under the name of Maarad, it outyields Sakel considerably.

Crosses between the two varieties have been made with the object of combining the satisfactory plant characters of Pima with the desirable lint qualities of Sakel. Two of these crosses, now in the eleventh and tenth generation, respectively, are decidedly promising. Both appear to be as well "fixed" and as uniform as the Pima variety itself.

MAARAD COMPARED WITH ARIZONA PIMA

Some 10 years ago Pima cotton was introduced from Arizona into Egypt. After several years' selection, a strain designated Maarad was judged worthy of distribution to growers. This cotton has been grown commercially in the Nile Delta during the last three years, and is said to yield on the average 25 per cent more lint per acre than Sakel, the principal long-staple variety of that country. Since the production of Maarad cotton in Egypt is increasing rapidly, and since the lint is claimed to be superior to that of Arizona Pima, it was thought advisable to make a comparative test. Seed received from Egypt was planted in 1927 at an isolated station in Arizona, by permission of the plant quarantine and control administration. With seed obtained from the 1927 planting, a row of Maarad was planted in 1928 at the Sacaton station, with a row of commercial Pima on one side of it and a row of 5–3 Pima on the other. As compared with the Arizona stocks of Pima, the lint of Maarad averaged shorter and showed greater variation in length. The evidence seems to warrant the conclusion that Maarad is merely a strain of Pima, not a distinct variety, and that when grown in Arizona under comparable conditions it is in no way superior to the original stock.

ROOT ROT

Recent developments in the study of the root rot of cotton in Texas and Arizona include several additions to our knowledge of the habits of the fungus that causes this very destructive disease. As a result of carefully recording and mapping of affected areas at Greenville, Tex., it is found that the growth of the root-rot spots is not continuous but is subject to recurring periods of decline or restriction of the disease to the extent that the fungus may survive in only a few small spots from a much larger area formed by several seasons of regular continuous growth. During the nine years of close observations and mapping of infested spots at the Greenville station, all of the spots have shown periods of regular annual growth for three to six years, with subsequent breaking up or reduction of the areas of infection, and often marked reductions with later resumptions of the normal outward growth as in the previous development of the spot. In some cases the fungus has almost completely disappeared, so that only a few small centers have survived from a previous large spot. Such behavior was considered at first as an effect of dry seasons, which undoubtedly restrict the spread of the disease, but some other factor apparently is involved, since the periodic breaking up of the spots has occurred independently of soil and seasonal conditions. Adjacent spots on the same soil have shown contrasting behavior in the same season, one spot definitely breaking up while another was in the stage of continuous growth.

Laboratory experiments in Arizona have shown that the fungus can live for long periods with only dead plant material to feed upon, and that growth of the fungus through the soil is not limited to the presence or proximity of roots, but may extend for 3 feet or more away from any roots. The ability of the fungus to grow for long periods on dead cotton roots and many other kinds of dead plant material has been demonstrated in the laboratory cultures, thus confirming other indications of the existence of the fungus in nature as a saprophyte. Living plants have been inoculated with the fungus after growing it for several months on dead tissues exclusively.

Another result obtained by the artificial cultivation of the root-rot fungus in Arizona is the discovery of hold-over bodies, or sclerotia. The formation of true sclerotia by the root-rot fungus was observed for the first time in laboratory cultures of the fungus at Sacaton, Ariz., in September, 1928, and subsequently great numbers of such bodies were produced on cultures of dead cotton-plant tissues in sterile sand. Germination of the sclerotia into new mycelium has been observed, and recently sclerotia have been discovered under field conditions in Texas.

The structure of the sclerotia indicates that they are simple storage bodies which may serve for preserving the organism during periods of inactivity. They apparently are not injured by widely fluctuating temperatures or by submergence in water for long periods, but seem not to withstand desiccation in the air. The sclerotia undoubtedly play an important rôle in maintaining the fungus through the winter and may furnish an explanation of variable and disappointing results with control measures in various places.

Experiments with barriers against the spread of root rot have been made at Greenville, Tex., with narrow trenches 12 and 24 inches deep, with results indicating that the advancing zone of the fungus mycelium is not deep seated in the soil at Greenville, perhaps not more than 15 inches below the surface. The 1-foot trench distinctly retarded the advance of the fungus, while the 2-foot trench was not passed except as the fungus grew around the ends of the barrier. Under field conditions in Arizona the fungus passed under an open trench 20 inches deep. Deeper penetration occurs in open soil or on dead roots of trees, to the extent of 4 feet or more below the surface. The fungus shows its presence by the growth of mycelium and the formation of spore bodies where moist soil is exposed on the sides of narrow trenches.

Applications of manure or green alfalfa applied in deep furrows before planting have materially reduced the amount of disease in the cotton fields in Arizona. Small isolated spots of root rot in cotton or other field crops can be eradicated by saturating the soil with strong disinfectants such as formaldehyde, cresylic acid, or carbon bisulphide, but these methods are too expensive for general use. Barriers of sheet iron, oiled earth, and open trenches have been tried where infection was extending into new areas, and have proved effective, though practicable only in special cases.

ABACA IN PANAMA

Abacá plants representing five different varieties of the introduction of 1925 were set out in 1927–28 in two fields of 10 hectares (about 25 acres) each on different kinds of soil near Almirante, Panama. This trial on a fairly large scale has demonstrated that these varieties will grow well on these two soils in Panama and that they are practically immune to the Panama disease of banana plants. A small fiber stripping test with older plants shows that they yield fiber fully equal to that from the same varieties in the Philippine Islands.

TALL PINK-BLOSSOM FLAX

In 1918 crosses were made between a tall blue-blossom fiber flax and a short pink-flowered mutation of seed flax. The object of the cross was to obtain a fiber flax with distinctive flowers, different from the ordinary blue-flowered or white-flowered flaxes. Numerous selections have been made from the progeny of these crosses, and finally one has been obtained equal in height to the tall blue-blossom fiber flax, very resistant to lodging and satisfactory in fiber production.

HEMPSEED

An exceptional flood of the Kentucky River in June and early July, 1928, destroyed nearly all of the seedhemp crop. Fortunately, Wisconsin hemp growers had seed left over from previous years, but studies on hempseed germination conducted in 1927–28 indicated that most of the seed more than 3 years old germinated very poorly. With the scanty supplies available, no good seed could be wasted. Practically every lot of hempseed in Wisconsin was tested. Seeds of low germination were discarded and the remainder blended so that the rate of seeding could be calculated from the average germination. This work made it possible to sow about 1,700 acres of hemp in Wisconsin in the spring of 1929 and obtain generally fair stands.

RUBBER PLANTS

HEVEA TREES IN FLORIDA

The Hevea or Para rubber tree of Brazil, the same species that has been planted extensively in the East Indies and in other tropical countries, has made rapid growth in Florida in the last two seasons, and many of the young trees have attained a height of 15 feet or more. No frost injuries occurred in the winter of 1928–29, and some of the Hevea trees with slathouse protection continued to grow, even during periods of cold weather. This is a further indication that the Hevea is much more resistant to cold than has been supposed, and that the development of strains sufficiently hardy to grow readily in southern Florida is not to be considered as beyond the range of a practical possibility. With protection against the sea breeze, the young Hevea trees have grown as rapidly in Florida as in Haiti or in Panama, and also more rapidly than the other rubber trees included in the Florida experiments. The single Hevea tree that has lived for many years under outdoor conditions at Palm Beach was broken off a few feet from the ground in the hurricane of 1928, by the fall of a larger neighboring tree, but has sprouted from the stump. According to the best information, this tree was planted in 1899, and thus has survived for about 30 years in a rather unfavorable location.

Experiments with the Hevea rubber tree in Florida, as well as in Haiti and Panama, are showing the existence of several specialized characters which largely determine the requirements for successful cultivation. The seedling and sapling stages are specially adapted for forest-undergrowth conditions, being extremely tolerant of shade and humidity, but they are very susceptible to damage or checking of growth by wind or dryness, especially if the soils are heavy and the humus layer deficient. Checking of growth by unfavorable conditions renders the seedlings very susceptible to attacks of red-spider mites, and the subsequent growth of many individuals is slow and abnormal, but resistance and recovery are shown when better conditions are restored. Open culture of the young plants is practicable where soil conditions are sufficiently good, but with the necessary protection of the early stages of growth a much wider range of cultivation becomes practicable.

EXPERIMENTS IN THE WEST INDIES AND CENTRAL AMERICA

After four years of tapping experiments conducted on a group of Hevea trees at Bayeux, on the north coast of Haiti, it appears that the local conditions are not unfavorable for producing rubber, since the yields are comparable with those reported from similar experiments in the East Indies.

The behavior of Hevea in other localities in Haiti and also at several places in the Canal Zone and in Panama is being tested and cooperative tests in Cuba, Honduras, and Ecuador have been arranged. Groups of Hevea trees are being grown at Summit and at several other points in the Canal Zone, to test the behavior of the trees and to afford local supplies of seed to facilitate larger plantings near the middle of the zone, where suitable locations exist for cultural experiments or larger field plantings, to determine the possibilities of commercial production in neighboring districts of Panama. Favorable records of regular tapping of Hevea trees in Jamaica have been secured, and other groups of normally developed Hevea trees are known to exist in Mexico and Central America. Many plantings of Castilla have been made in the West Indies, and experiments indicate that Hevea probably can be grown in any localities that are favorable for Castilla, though the growth of the seedlings and saplings of Hevea may be slower at first, or until the young trees are well established.

NEW PLANTS FROM MADAGASCAR

Recently a new series of rubber plants has been obtained in Madagascar. The genera Mascarenhasia, Pachypodium, Secamone, Cryptostegia, Gonocrypta, Marsdenia, and Euphorbia are represented, and several lots of seed from rubber-bearing plants whose botanical identity was not determined. Most of this material came from the southern part of Madagascar, which has a rather temperate, dry climate. The most important rubber plant in the collection is *Euphorbia intisy*, a plant rapidly becoming rare in Madagascar which may prove to be adapted to desert conditions in the Southwestern States. It produces a good quality of rubber, which formerly was an article of export from Madagascar.

FOREST-TREE DISEASES

CHESTNUT BLIGHT

The expedition in Asia for the purpose of procuring seed of blight-resistant chestnuts has met with marked success. Seeds of the forest type of Japanese chestnut from all of the important chestnut regions of Japan have been successfully shipped to this country in considerable quantities, and the seedlings are now growing in nurseries near Washington. Most of these seedlings will be planted out in test plots, in selected localities in the eastern chestnut region in the southern Appalachians, where the chestnut-tannin-extract and chestnut-board industries are located. The forest type of Japanese chestnut is not as tall nor as straight a tree as the American chestnut, but in Japan it makes a fair-sized tree valuable for railroad ties, fence posts, and other uses, in addition to supplying edible nuts. Many sections of trees from different parts of Japan have been secured for tannin determinations, and the preliminary analyses indicate that the tannin content of the Japanese chestnut is higher than that of the American chestnut. Of particular promise is a northern Chinese chestnut with large nuts; this seems adapted for orchard culture and appears to come true from seed.

Surveys and reports from many cooperators indicate that the chestnut blight is continuing its steady spread throughout the southern Appalachians. Several counties in Georgia, near the southern edge of the large commercial stands, have now reached the stage in which 80 per cent or more of the trees are infected, and practically all of the important chestnut counties have 10 per cent or more of the trees infected.

EUROPEAN LARCH CANKER

It was possible to do only a limited amount of work on European larch canker prior to March, 1929, when an appropriation to carry on the work became available. The outstanding result up to the present time is the destruction of all definitely known cases of the disease. This has been accomplished through the cooperation of the owners of the trees and the State authorities of Massachusetts and Rhode Island. No new cases of the disease have since been found, but scouting is being continued and it is believed that other cases are certain to be found. So far the disease fortunately has been found in relatively few places and singularly restricted in distribution in those localities. It very probably occurs only where it has been brought in upon diseased nursery stock. The suspicious cases on tamarack, previously reported from Maine and Vermont, are not this disease, although their exact identity is yet to be determined. Preliminary studies of the fungi associated with the several diseased hosts indicate that we may be dealing here with two diseases instead of one. This possibility complicates the work of practical control as well as the technical aspects of the problem.

CORYNEUM CANKER OF CYPRESS

In 1927 attention was called to an apparently new bark disease which was killing twigs, branches, and often entire trees of Monterey and Italian cypress at Palo Alto, Calif. The disease has since been found on *Cupressus lusitanica*. It is due to an undescribed fungus of the genus Coryneum, apparently new to North America. The disease is now general around San Francisco Bay, except in the city of San Francisco, and extends north in the interior valley to Sacramento. It has also been found in several localities in the coast valleys from Santa Clara into San Luis Obispo Counties, as well as in two small areas in southern California. It apparently has not been present in any of these localities for more than six or eight years. A short survey, in cooperation with the county horticultural commissioner, was made of the Monterey Peninsula and the adjoining coast as far south as Point Lobos. This area contains the only native trees of Monterey cypress, and cultivated trees of this species are also planted there by the thousand. The native trees particularly are famous and have a very high esthetic value. The disease was not found in the area, and there appears to be a very fair chance of keeping it out. Recommendations for a further survey and for extreme vigilance in connection with movement of cypress nursery stock have been made. This disease has not yet been found outside of California. It is to be looked for in Arizona and New Mexico, where its hosts are extensively grown.

WHITE-PINE BLISTER RUST

Exceptionally favorable weather conditions in 1927 and 1928 caused a further widespread distribution of white-pine blister rust in both the eastern and western United States. During these years the rust spread southward on Ribes through the coast and Cascade Mountain regions into the northern limits of the sugar pine in Oregon. This new extension of the rust toward the chief sugar-pine areas of southern Oregon and California indicates that these areas may become infected within a comparatively short period of years as a result of the natural spread of the disease.

In 1928 the rust was found on Ribes at 33 points throughout the principal western white-pine belt of the inland empire (western Montana, northern Idaho, and northeastern Washington). It is believed that a number of the infections found on Ribes in 1928 resulted from long-distance spread of wind-blown spores. However, a more thorough examination of the pines in 1929 in certain localities in Idaho where the rust was abundant on the Ribes in 1928 has revealed local pine infections in four cases. Throughout this region western white pine (*Pinus monticola*) is the most valuable forest-tree species. It is highly susceptible to the blister rust, and heavy losses will result unless effective control measures are applied.

The bureau is cooperating with the Forest Service and the States concerned in the systematic eradication of the stream-type Ribes, which are highly susceptible, as a necessary measure to avert heavy immediate losses to the pine. Following this work, systematic control will need to be extended over the remaining area as rapidly as practicable. An outstanding feature of the work in the Western States during the last two seasons has been the successful development of chemical eradication of Ribes on stream-type areas. The toxic effects of a number of chemicals have been tested and methods of application worked out, with the result that a more effective and cheaper eradication of Ribes in the stream type is assured.

In New England and New York blister rust is steadily increasing in the unprotected areas. However, in these States the situation is well in hand, the pine areas are being successfully protected by systematic Ribes eradication on more than 800,000 acres annually, and there is every assurance that control can be maintained at low cost.

In Michigan, Wisconsin, Minnesota, and Pennsylvania the disease is spreading much more rapidly than heretofore. Limited scouting for the disease in northern Maryland, Virginia, and West Virginia gave negative results, but the rust will undoubtedly reach these States within a comparatively short time. These States are increasing the cooperative blister-rust control activities to meet the more critical situations brought about by the rapid spread of the disease.

WILLOW SCAB

Although very little work on willow scab has been done in this bureau, the aspect of this extraordinary disease is in some ways so threatening as to warrant discussion in this report. It has been mainly investigated in the United

States by the Connecticut Agricultural Experiment Station and in Canada by the Dominion botanist.

Willow scab has been known for many years in Europe, where it is serious only locally or in certain years. It does not appear to have been observed on this continent prior to 1927. It is now widespread throughout Nova Scotia, Cape Breton Island, Prince Edward Island, New Brunswick, and eastern Maine, and occurs more scatteringly in Quebec, western Maine, New Hampshire, Massachusetts, Connecticut, and eastern New York. It is very destructive in the eastern Provinces, killing even large trees in a single year. Apparently it kills its host trees more rapidly than the chestnut blight; but whether it is likely to follow as steady a course, essentially unaffected by climate and locality, is not known. There is no present agreement as to whether some species and varieties of willow are more resistant than others.

Two fungi appear to be associated with the disease, *Fusicladium salici-perdum* (All. and Tub.) Tub. and *Physalospora miyabeana* Fuk. Agreement is far from complete as to which is the primary parasite. So far as is now known both of these fungi are new to North America.

Willows are not of present importance as timber trees, and constitute a minor element in planting for ornament and shade. Willows are, however, an important element in shelter-belt planting in many parts of the West, and are of fundamental importance in both natural and artificial stream and flood control. It is this last fact that makes the present issue of potentially serious import. If the native willows of North America should follow the chestnut into virtual extinction, there can be little doubt that many streams now held in place by willows naturally or artificially planted on their banks would form new channels or widen their beds, with the most disastrous results.

WOODGATE RUST

It was not possible to do much work on Woodgate rust in 1928. So far as known, the disease is not present in the United States outside of New York; it has, however, been reported recently from the Provinces of Ontario, Quebec, and Nova Scotia, on the same host as in New York—Scotch pine. The infection in Canada is said to be as old as that in New York, and there is no clear evidence of spread in either direction. Probably the Canadian and New York infections are the result of separate introductions. The Woodgate rust must still be regarded as an active menace to the hard pines of the Eastern and Southern States, if not to those of the entire continent. The exact measure of danger can not be known until the identity of the disease is determined and its place of origin known.

DRY-LAND AGRICULTURE

In 1905 this bureau instituted investigation of the problems of agricultural and horticultural development of the Great Plains area. This area includes all of Montana, North Dakota, South Dakota, Nebraska, Wyoming, Colorado, Kansas, Oklahoma, Texas, and New Mexico lying between the 5,000-foot contour on the eastern slope of the Rocky Mountains and the ninety-eighth meridian of longitude. All this region is classed as semiarid; the normal annual precipitation ranges from as low as 10 inches to as high as 30 inches, by far the larger portion of it, however, having from 12 to 15 inches; consequently the all-important major problem of the agriculture of this entire region is the conservation of moisture. Field stations and cooperative experiments are maintained throughout this region, and a vast store of basic data on the possibilities of crop production on the Great Plains has been secured.

During the past year land has been broken for the establishment of a new station, to be known as the Central Great Plains Field Station, near Cheyenne, Wyo. Many of the families coming into the high plains to live are from more eastern regions and are accustomed to gardens and home-grown fruits and to the protection of their farmsteads by shade trees. On the plains they find neither timber nor fruit trees, except those growing sparsely along the streams. Under these conditions, vegetable gardens have largely failed, so that the farmers of this general region depend almost entirely upon commercially canned fruits and vegetables in place of the home-grown products that should be furnished from the farm gardens.

Experimental work already done by the bureau in the restricted area of the northern Great Plains where such work has been under way indicates that with the establishment of effective shelter belts such fruit as grapes, cherries, plums, and peaches and such garden truck as potatoes, rhubarb, sweet corn, asparagus, etc., can be success-

fully grown on a scale that would be of material benefit in the region. At this new station at Cheyenne, shade, ornamental, fruit, and shelter-belt trees, shrubs, vines, and vegetables adapted to the needs of the semiarid or dry-land regions of the United States are being propagated, and cuttings and seeds will be placed with cooperating farmers for experimental and demonstration purposes within the area.

IRRIGATION AGRICULTURE

The immediate problems that are essential to successful agriculture on the irrigated projects of the West have proved to be mainly the following: (1) Determination of the most profitable crops, (2) securing relatively large yields of these crops through the adoption of proper farming practices, (3) the profitable utilization of crops grown for purposes of soil improvement, and (4) the adoption of irrigation practices which will not impair the productivity of the soil by the accumulation of harmful quantities of salts in the root zone.

The investigational work of the various irrigation field stations has been so planned that authentic information on the above phases of crop production under irrigation may be available to the farmers on the projects where the stations are located as well as on adjoining irrigated areas.

One of the most substantial contributions the field stations have made to agriculture on the projects has been in determining through extensive experiments the effects on yields of the major cash crops of various crop sequences and cultural treatments. On three of the more important field stations the present season will complete the eighteenth year of these tests. The information now available through these investigations of the beneficial effects of alfalfa in a well-planned crop rotation on crop yields is having a notably favorable effect on the economic conditions of the projects. The results thus made available are disseminated through publications, numerous visits by farmers to the stations, and field-day meetings when farmers from the projects gather for the purpose of observing the results.

On the irrigated projects of the West alfalfa is recognized as being the most useful and widely grown crop for maintaining and improving the productivity of the soil. As the distances to consuming markets are usually too great to permit alfalfa to be profitably grown as a cash crop, and as it has been essential to devote large acreages for soil-improvement purposes, the utilization of alfalfa so that it will not be too great a liability on the cash crops produced has presented a real problem. The field stations where this condition exists have been devoting particular attention to this phase of agriculture. The information made available has demonstrated that alfalfa and like soil-improvement crops may be grown at a profit rather than at a loss or barely covering production costs. This has been made possible through investigations in lamb feeding, the lambs being purchased in the fall and marketed in the spring; through the possibilities of fattening hogs on alfalfa; and by demonstrating that the dairy industry may be conservatively expanded. This has recently stimulated alfalfa production, which has been materially influential in favorably affecting crop yields and thereby improving the general economic conditions of a number of the projects.

BORON INJURY FROM IRRIGATION WATERS

A problem that has recently developed in certain areas of the southwestern irrigated sections is the boron injury to citrus and walnut trees. It has been ascertained that boron occurring in irrigation waters is considerably more widely distributed than was at first supposed. Field surveys and analyses of irrigation-water supplies have been made, and it has been shown that the sources of contamination are usually localized, and thus it is possible to reduce the boron concentration of certain water supplies by withholding or diverting those chiefly contributing boron. Physiological investigations under definitely controlled conditions, supported by field observations, have indicated that there is a wide variation in the tolerance of crop plants to boron. As a result it is believed that it will be possible to segregate those waters with a relatively high boron content and utilize them on boron-resistant crops, and in consequence reduce the boron concentration in the remaining water supply to be used on less tolerant crops.

APPLICATION OF GYPSUM

When it is desired to improve the physical condition of the soil for the purpose of obtaining better penetration of irrigation water, it has been found that an application of gypsum is beneficial. Ordinarily dry, finely pulverized gypsum is scattered over the

soil and plowed under or harrowed in. This practice has not proved to be wholly satisfactory, largely because the method was wasteful and inefficient. Attempts to apply gypsum in solution by pouring the dry material into an irrigation stream also gave unsatisfactory results. An apparatus was recently devised and tested at the Newlands (Nev.) field station which has proved very satisfactory. This machine is relatively inexpensive; it dusts the material into the water, which is stirred vigorously to expedite solution. Its installation does not seriously involve a loss of head in the irrigation ditch. It seems likely that this method of applying gypsum will come into general use when its advantages are more widely known.

LABORATORY EXPERIMENTS WITH PAPER MULCH

Covering the soil with an impervious black paper has been found to stimulate the growth of seedlings in greenhouse flats, as well as in the field, thus making possible the study of the effect of paper mulch under controlled laboratory conditions.

The technic adopted is a modification of that developed in electroculture and is based on the mean elongation or weight of 100 seedlings grown in small flats placed on a revolving table to insure uniform exposure. An increased growth rate of the order of 3 per cent can be detected by this method, and an experiment can be completed in two weeks instead of requiring the whole season as in field trials.

The results up to the present time indicate that (1) white paper is practically as effective as black; (2) a transparent but impervious covering is effective; (3) the major effect is on the soil and not directly on the growing plant; (4) the improved condition in soil persists for some time after the paper is removed; (5) changes in soil temperature and moisture relations may produce measurable effects but are not directly responsible for any large part of the increased growth; and (6) the beneficial effect of the covering is dependent on soil organisms. In sterilized soils there is little or no stimulation associated with the use of paper.

EFFECT OF LIGHT PERIODS

Continuing the study of effects of short alternations of light and darkness on plant growth and development, observations have been made with long-day and short-day types of plants exposed to discontinuous illumination, with the total daily light exposures aggregating eight hours in all cases. The single daily light exposure of eight hours, of course, gives the typical short-day effect. As the alternations are progressively shortened (the light period in each case being half the period of darkness), plant growth is correspondingly reduced until a minimum is reached with the alternation of 40 seconds of light and 80 seconds of darkness. Further shortening of the alternations results in decided improvement in growth. The effects, in general, are similar to those previously obtained with alternations of equal light and darkness, except that the nutrition of the plants has not been as well maintained. Although the light periods are only one-half as long as the periods of darkness, the formative effects of all the shorter alternations on both long-day and short-day plants are those of a long day or continuous illumination.

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REPORT OF THE CHIEF OF THE PLANT QUARANTINE AND CONTROL ADMINISTRATION

UNITED STATES DEPARTMENT OF AGRICULTURE,
PLANT QUARANTINE AND CONTROL ADMINISTRATION,
Washington, D. C., August 31, 1929.

SIR: I submit herewith a report of the work of the Plant Quarantine and Control Administration for the fiscal year ended June 30, 1929.

Respectfully,

C. L. MARLATT, *Chief.*

Hon. ARTHUR M. HYDE,
Secretary of Agriculture.

INTRODUCTION

The reorganization of last year centralized the regulatory and law enforcement activities of the department relating to plant pests under the newly organized Plant Quarantine and Control Administration. This new organization took over the work which had theretofore been carried by the Federal Horticultural Board and, in cooperation with the latter, by the Bureau of Entomology and the Bureau of Plant Industry. This included the enforcement of all quarantines issued under the authority of the plant quarantine act of 1912 and the related Mexican border act; the insect pest act of 1905; in cooperation with the Post Office Department, the terminal inspection act of 1915, and the act of 1926 authorizing inspection and certification of exports to meet the sanitary requirements of foreign countries. Included in these transfers, also, was the administration and direction of important control and eradication projects with respect to certain recently introduced pests such as the gipsy moth, European corn borer, Japanese beetle, etc.

The first year's work of the Plant Quarantine and Control Administration has fully demonstrated the advantages resulting from the unification of direction of such quarantine and closely related control work. For example, under the reorganization and the appropriation language carrying the different items as subappropriations it was possible for the Secretary of Agriculture to meet with immediate support the emergency occasioned by the outbreak of the Mediterranean fruit fly in Florida. Further advantage has arisen from the ease with which personnel and equipment can be transferred from one project to another in response to seasonal changes or sudden developments. Increased efficiency and material financial savings have also resulted from the reorganization.

Five new dangerous insect and plant disease infestations have been made the subject of Federal plant quarantines during the fiscal year. These are the Woodgate rust, a disease of unknown origin attacking hard pines in northern New York State; the phony disease of peaches, which is retarding peach production in Georgia and which has recently been demonstrated to be a communicable infection; the Asiatic beetle and the Asiatic garden beetle, which only in recent years have come into prominence as dangerous pests but which, according

to available records, were probably introduced with soil about plants prior to the passage of the plant quarantine act of 1912; and the Mediterranean fruit fly.

Necessarily the major interest will attach to the establishment of the Mediterranean fruit fly in Florida, which constitutes perhaps the most serious emergency ever faced by American horticulture. This report, therefore, gives a fairly extended and informing statement with respect to the work on this subject by the Plant Quarantine and Control Administration in cooperation with the State of Florida and with other States.

The tables included in this report have been continued from year to year and constitute a record of distinct reference value not available elsewhere. Important among these tables are records of importations of restricted plants and plant products—records which give details as to the different kinds of fruits or vegetables or other plant products, and as to the countries of origin and ports of entry. Other tables give summaries in relation to the enforcement of important plant pest quarantines.

As indicated in former reports, the quarterly Service and Regulatory Announcements, published by the Administration, constitute a permanent record of new quarantines and of revisions and modifications of those already in force. The final number of these announcements for each year contains a complete annotated list of the current quarantines, domestic and foreign, as well as all other restrictive orders. In connection with these announcements, there is also published at the end of each year, under the designation "Annual Letter of Information," a list of pests collected from imported plants and plant products during the previous year. This list is accompanied by explanatory notes, and with each pest interception, there is given the host plant or article, country of origin, and the American port of interception.

DOMESTIC PLANT QUARANTINES

THE MEDITERRANEAN FRUIT FLY

CONTROLS IMMEDIATELY STARTED

The Mediterranean fruit fly was found to be rather widely established in Florida early in April of this year. The seriousness of this situation was at once recognized generally throughout the United States, as was also the fact that every effort should be made to eradicate this pest. An emergency fund of $50,000 was immediately made available by Florida, and State forces were mobilized in efforts looking to eradication. The large and well-organized plant-quarantine personnel of the State was thrown into this work, as were extension-service workers, technical leaders from the State experiment station, and the hundreds of citizens offering voluntary aid. The Federal Government, upon the recommendation of the Secretary of Agriculture, approved by the President and Congress, made $4,250,000 immediately available for the control and eradication work, which had already been started by the Plant Quarantine and Control Administration of the Department of Agriculture, in cooperation with Florida, on a transfer of $40,000 from the administration's funds and personnel from other work of the administration.

Steps were at once taken (1) to determine the extent of the spread of the pest in Florida and elsewhere, (2) to destroy all fruit in infested and surrounding orchards, and (3) to spray the trees concerned with an attractive poison bait as a substitute for the natural food thus removed. Pending quarantine action, the growers concerned were brought into agreement not to ship any fruit from the known infested groves or from the immediate vicinity of such groves except under permission of the State plant board.

QUARANTINE ACTION

Conferences between the chief of the Plant Quarantine and Control Administration and the State Plant Board of Florida held at Orlando and later at Gainesville resulted in the promulgation on April 15 of a State quarantine covering the then known area of infestation, together with a wide protective zone. The restrictions of this quarantine were applied to new areas as rapidly as these were determined. Federal quarantine action followed as soon as the required legal notices permitted. This quarantine, as promulgated April 26, covered the entire State of Florida and was immediately effective as to all areas in that State which had been found to be infested, and throughout the State on May 1.

The very considerable enlargement of known infestation in the central part of Florida during the first half of May indicated sufficient uncertainty as to the extent of the infestation to warrant additional restrictions on

fruit and vegetable movement, and on May 16 the quarantine was amended to prohibit movement of host fruits and vegetables from any part of Florida into the cotton States from North Carolina and Tennessee southward and westward including Arkansas, Oklahoma, Arizona, New Mexico, and all States south of these, and also California, Nevada, Utah, Idaho, Oregon, and Washington. This action took into account the greater risk of the fruit fly to these States, than to Northern and Northeastern States.

A number of minor amendments not here noted have been made both to the State and to the Federal quarantines to meet various needs as they have arisen.

WIDE DISTRIBUTION OF FRUIT FROM INFESTED AREAS

Prior to the discovery of the establishment of this pest at Orlando, Fla., on April 6 and the confirmation of its identification in Washington on April 10, more than three-quarters of the fruit of that district and of Florida had already moved out of the State through the normal channels of distribution, thus carrying the risk of spreading this pest widely in the United States. Much of the movement to the near-by States of Georgia and Alabama and perhaps Misssisippi had been by autotruck and had consisted of fruit of lower grade, often culls, which were therefore especially open to the possibility of being infested. The more western of the States indicated had also been reached by fruit in bulk rail shipments as well as by fruit crated and shipped in refrigerator cars. Much of this fruit had been consumed, but a considerable portion of it, together with fruit shipped from points more recently determined as infested, was still held in local markets or in storage in the States of destination.

COTTON BELT STATES MOBILIZED

The likelihood of carriage of infested fruit into the Cotton Belt States was obvious, and even prior to the taking of Federal quarantine action the nature of this risk was brought to the attention of the appropriate officials of these States in communications of April 23, in which such officials were urged to have inspections made of all Florida fruit in markets or storage so that any infested shipments might be destroyed. Later on, as the widespread character of the infestation in Florida was determined, these States, on my suggestion, were notified of this risk by the Florida State Plant Commissioner, Wilmon Newell, and on the same date (May 10) the seriousness of this situation was confirmed by a telegram from the Plant Quarantine and Control Administration again urging inspection and destruction of infested fruit, and a clean-up of containers and locations where such fruit had been kept. A call was issued at this time for a conference at Atlanta of quarantine officials in the cotton States from Texas eastward. At this conference, held on May 15, plans were made for Federal cooperation in clean-up and control work in these States. A total of approximately $200,000 was contributed for this purpose from the special fruit-fly appropriation.

In many of the cotton States as much work of this nature had already been started as the available funds and personnel permitted. It was appreciated, however, that the work would have to be pushed to a rapid completion or the larvæ in the fruit would emerge and find soil or other safe situations in which to pupate. This necessity led to the request at Atlanta that the State extension services of all the States from Texas and Oklahoma eastward should be brought into this effort to locate and inspect Florida fruit, particularly grapefruit, in view of the impossibility of securing promptly a sufficient number of persons with the general training necessary for this work. Such cooperation was approved by the director of extension work of the Department of Agriculture, and notification to that effect was transmitted to the appropriate State and district leaders. At the same time even more intimate and widespread cooperation was secured by enlisting the services of home demonstration agents of the extension service.

This work resulted in the discovery of 14 shipments of infested fruit—a good deal of it in carload lots—distributed to 10 localities in the following States: Arkansas, Georgia, Louisiana, North Carolina, and Texas. One of the infestations in North Carolina, that at Raleigh, was based on the discovery of adult flies which had emerged in a small grocery store from infested Florida fruit. Intensive clean-up operations were conducted at this point by the State officials with Federal cooperation. Additional instances of infested fruit were reported from New York (2) and Ohio (1).

Much of the fruit which had moved into the Southern States during the winter and spring of 1928–29 had been consumed or disposed of prior to this survey, but there remained undoubtedly a large risk that the fly might later appear in these States in local orchards or gardens. The cooperative inspection work under Federal and State aid was therefore continued throughout the summer, and lasted through the peach season in Georgia and Alabama and generally through the fruit season in the other States. Up to the time of the preparation of this report no appearance of fruit fly had been determined anywhere outside of the central area of Florida—a situation which greatly favors success in the eradication effort.

METHOD OF ENTRY

The method of entry of this pest into the United States is unknown. It has wide distribution throughout the world, and the effort to prevent its entry into the United States has been continuous since the passage of the plant quarantine act of 1912, both through quarantines prohibiting entry of known host fruits and vegetables from countries which have been reached by the fly, and by inspection and quarantine enforcement at the ports of the United States. Such inspection has resulted in many interceptions of infested fruit, and the possibility of the entry of the fruit fly by such means has thus been clearly shown. The forces available for such port inspection, however, have been very inadequate, although it has been possible to increase the service from year to year. That entry must have been gained through the bringing into this country by some person, either in ignorance or maliciously, of infested fruits or vegetables seems obvious.

STATUS OF INFESTATION

In the early stages of the work it was determined that the fly was thoroughly established in several orchards within the town limits of Orlando, and at a few outlying points not more than 6 miles north and south. The later determinations of spread have confirmed the idea that Orlando was the starting point of the invasion, particularly as no infestations of a like intensity have been found elsewhere.

The status of the infestation throughout the area as now determined, as a result of the scouting of the entire State during the past four months, has confirmed the original idea that this pest is of recent introduction, and that its introduction occurred perhaps sometime during the spring or summer of 1928. In other words, the extent of spread can easily be accounted for by the movement of citrus during the last season—fall, winter, and spring. The intensity of infestation in a few orchards in Orlando is easily accounted for by the high rate of multiplication of the insect—a rate which if only one-third or one-fourth the possible rate of increase, in the presence of abundant fruit as at Orlando, would mean the production of 10,000,000,000 insects by the fifth generation, and this number of generations would require a summer period of less than four months.

The fruit fly has now (August, 1929) been found in more than 980 localities in 20 counties within the central and northern part of the peninsular portion of Florida. The protective area surrounding these points of infestation which has been included in the quarantined area, involves altogether upward of 8,100,000 land acres. Approximately 67 per cent of the bearing citrus trees of Florida are included in this area and, on the basis of a 3-year average, 76 per cent of the citrus fruit moved from that State.

Although considerable scouting has been done in other parts of Florida and, as elsewhere indicated, in the States within the Cotton Belt, no field infestation of the fruit fly has been found outside of the area mentioned above. While it is impossible, at this time, to state with assurance that the infested area has been completely delimited, the fact that no infestations have recently been found outside of the general area as now determined is most encouraging.

HOST FRUITS AND VEGETABLES

The fruit fly can breed in practically all fruits, the only important exceptions so far determined being watermelons, pineapples, strawberries, lemons, sour limes, and nuts. The important vegetables produced in Florida which are subject to attack are peppers of all kinds, tomatoes, eggplants, and Lima and broad beans. The fruits, except as indicated, and the listed vegetables are those now subject to restriction as to movement. In Florida the fly has demonstrated a special liking for grapefruit and sour orange, among the citrus fruits, although being able to propagate in all citrus fruits other than in the lemon

and sour lime. Other freely attacked fruits commonly produced in Florida are the guava, fig, Surinam cherry, mango, avocado, peach, and pear.

ERADICATION MEASURES

The program or means of eradication developed naturally in the early days of the work. It included (1) intensive inspections which were ultimately extended throughout Florida and, as a follow-up of movement of Florida products, throughout the Cotton Belt States; (2) the clean-up in Florida of infested properties as rapidly as found; (3) the spraying of trees on such infested properties and adjacent properties with sweetened poison bait to destroy adult flies, (4) for the purpose of maintaining a summer host fruit and host vegetable free period, the destruction of all summer-ripening fruit and the prohibition of summer-ripening vegetables in both infested and surrounding protective zones, and (5) in the infested zones, the removal of all citrus and other host fruits or host vegetables (throughout the year) prior to their reaching a stage of maturity susceptible to the fly, and, as to host vegetables, the prohibition of planting such vegetables "until the State plant board, with the approval of the United States Department of Agriculture, shall determine that all infestation in such zone has been eliminated and that the restrictions of this paragraph shall no longer remain in force with respect thereto." The enforcement of Federal and State quarantines for the prevention of spread of the fruit fly has supplemented these eradication measures by requirement of orchard and packing-house controls, control of transportation in intrastate and interstate commerce, control of motor-vehicle and other road movement and other features of sanitation and protection enforced under State authority within the infested and protective areas.

Destruction of fruit.—Prior to August 1, more than 580,000 boxes of citrus fruit, 3,400 bushels of vegetables, and 7,100 bushels of noncitrus fruits were destroyed. Not all of these host fruits and vegetables were actually infested, but were included in the order because produced in or within 1 mile of the infested properties. More than three-quarters of the citrus fruit had been marketed before the fly was discovered in Florida, and a great deal of the remaining marketable fruit was later shipped out of the State, namely, all fruit shipped from regions prior to the determination of presence of the fly. A large portion of the citrus fruit destroyed represents culls and drops which would have had no market value. A considerable number of owners, however, who had not marketed their fruit, lost their entire crop. No reimbursement has been requested for such destruction of fruit of the crop of 1928–29, and no reimbursement for such fruit is now contemplated.

Spraying.—Following the destruction of the infested fruit, the next step was to eliminate the flies remaining in the district to prevent their migrating elsewhere. To accomplish this, the infested groves and others within 1 mile of any point of infestation, were sprayed with a sweetened poison bait, and these sprayings were repeated at frequent intervals—if possible, every week, and at the beginning in the heavily infested areas even oftener. Space does not permit a description of the remarkable efficiency of such spraying which resulted in the almost complete elimination of flies in infested groves and trees by the second or third day. Neither is it possible to do more than indicate the tremendous volume of the work of fruit destruction and spraying which, at the height of the season, required the services of upward of 5,000 men, of whom 300 or more were directors of work and the rest laborers, and of all available trucks, spraying machinery, etc., which could be secured by loan or purchase, and the establishment of a depot of machines and supplies, much as in war times.

Destruction of summer hosts.—It was agreed by State and Federal authorities and others interested that the program which had been adopted in the case of the Mexican fruit-fly invasion in the lower Rio Grande Valley was essential to eradication of the Mediterranean fruit fly in Florida, namely, the establishment of a summer starvation period within the infested and protective zones during which there would be a complete elimination of all host fruits and vegetables in a stage of growth attractive to the fly, and, in lieu of such source of normal food, to supply the flies with an attractive substitute in the form of a sweetened poison bait to be sprayed on trees in orchards and elsewhere at frequent intervals. The effectiveness of this method has been fully demonstrated in the work so far, and the hope of eradication is largely centered on its intensification and continuance. It involves, however, cooperation on the part of every citizen of the State, and

the acceptance by such citizens of very material sacrifices inasmuch as it will mean, if success is to be achieved, the elimination—grubbing up or cutting down—of the trees or shrubs ripening fruit during the starvation period, as well as the prohibition of the growth of host vegetables during that period. This need of the destruction of plants comes from the impracticability which has been fully demonstrated of the daily or weekly removal of ripening fruits and vegetables from such areas. This giving up during the period necessary to eradicate the fly of cherished yard or garden plants and commercial or other plantings of the type indicated, in the interest of the major citrus industry, is recognized as a hard requirement of the citizens of the State, but one which seems to be absolutely necessary if the fruit fly is to be eliminated.

REVISION OF ERADICATION PROGRAM

The rapid additions to the infested areas as determined from week to week resulted in greatly expanding the work of clean-up of the orchards concerned and of application of poison bait to such orchards, and also of elimination of summer host fruits. To meet this situation the help of growers and others was enlisted, but even with such assistance in cleaning and spraying groves there remained uncared for the strictly residential properties, abandoned properties, and roadsides, as well as vast areas of noncommercial lands. It became apparent early in June that to carry out the program of clean-up of orchards and control of minor host fruits throughout both the infested and protective zones, and particularly to provide for the removal of all host citrus fruits in the orchards within the infested area, would involve enormous expenditures. Estimates of such expenditures requested at that time indicated a total cost of $12,550,000 for carrying out this program for the first quarter of the next fiscal year—July, August, and September, 1929—the period during which most of this work would have to be completed. The cost of the removal of the citrus fruit from infested zones alone was estimated at $6,300,000, and the clean-up and removal of noncitrus fruit in the protective zone at $6,000,000.

In addition to these items there were the necessary cost of administration, quarantine enforcement, inspection throughout Florida and other States, certification of products, and research work. The importance of the research field may be indicated by the fact that it furnishes the basis both for the eradication program and should the eradication effort fail, for the future control of the fly.

To meet the estimated cost of these various types of work, which totaled approximately $15,500,000 for the fiscal year 1930, there was indicated a probable balance of $3,000,000 from the original appropriation, or a deficit of $11,500,000.

The magnitude of the problem as thus developed, together with its nation-wide concern, led the Secretary of Agriculture to seek the advice, both as to the work above outlined and as to the possibility of eradication, of leading specialists selected from various parts of the country.

The committee thus appointed consisted of Vernon Kellogg, permanent secretary, National Research Council, Washington, D. C.; H. A. Morgan, president, University of Tennessee; T. P. Cooper, dean, College of Agriculture, director of extension work, Lexington, Ky.; Victor R. Gardener, director, State experiment station and professor of horticulture, State College, East Lansing, Mich.; T. P. Headlee, professor of entomology, Rutgers College, New Brunswick, State entomologist of New Jersey, and entomologist of State experiment station; G. A. Dean, head, department of entomology, State Agricultural College, and entomologist, State experiment station, Manhattan, Kans.; and H. J. Quayle, professor of entomology, University of California, and entomologist of Citrus Experiment Station, Riverside.

These specialists, after a field survey of the situation in Florida, submitted a report emphasizing their belief that eradication was not only practicable but an economic necessity. They further recommended the very considerable enlargement of the work now under way and the modification of regulations which in their belief would permit, under a system of sterilization, the interstate movement of citrus fruits from areas which previously had been considered infested without risk of spreading the pest. At the time of the visit of this committee to Florida, the research unit of the Bureau of Entomology, cooperating with the Plant Quarantine and Control Administration, had just completed work which indicated the practicability of such control of the larvæ and eggs in the fruit either by refrigerating to 28° F. or by heating to 110°.

The committee stated that such sterilization of whole fruit could, in their judgment, be accepted as a substitute for the destruction of the mature crop in the formerly infested areas and thus do away with the great costs ($6,300,000) already indicated for the removal of all citrus and other fruit of the coming crop in such areas, as well as the necessity for the reimbursement from the National Treasury to the growers of such fruit, estimated at an additional $10,000,000. This reimbursement idea had in fact already been indorsed in principle by the Secretary of Agriculture and had received the approval of the Bureau of the Budget in the customary language that the expenditures contemplated "would not be in conflict with the financial program of the President."

The report of the committee is, therefore, an indorsement of the means of eradication which had been developed by the administration except as to the substitution for the proposed destruction of fruit in zones which had, at any time, been determined as infested, of the methods of sterilization already noted.

After careful consideration, the report of these specialists was adopted, and the regulations under the fruit-fly quarantine were revised to carry out the enlarged program outlined in that report.

To carry out this program for the remainder of the present fiscal year it is estimated that in addition to the funds now available, $26,600,000 will be needed, and steps have been taken for the presentation to Congress of an emergency item of that amount.

This estimate covers the necessary Federal expenditures in the aid of the eradication effort but does not include those phases of the work which it is possible for the citizens of Florida to perform, such as the eradication in commercial properties of minor hosts and the spraying and crop clean-up in such properties, and as to these same features so far as possible also in residential or other properties. Further, as to commercial properties, it is understood that the additional work and costs required under the eradication program which relate to the required sanitary measures and to the requirements of handling and marketing of crops are to be borne by the growers and shippers.

There are, however, certain phases of the work which can not be thus delegated, and the estimate provides that the Federal Government, in cooperation with the State, shall be responsible for (1) supervision of the spraying and clean-up done by owners, (2) the clean-up of wild and noncommercial lands, abandoned properties, etc., (3) the spraying of roadsides, town properties, and wild land, (4) necessary scouting throughout Florida and other States, (5) the certification of products, (6) the supervision of sterilization, and (7) the enforcement of quarantine regulations.

The burden of eradication of any pest of this sort must necessarily fall very heavily on the State which has the misfortune to harbor a new and serious pest of this nature. Taking into account the existing financial situation in that State, Florida has contributed and is contributing largely in personnel and funds. Its citizens must necessarily absorb the additional production and marketing costs necessitated by the requirements of orchard sanitation, limitations on the season for harvesting and sale of the crop, and limitations on distribution areas—costs and losses which together will pretty well divide, between the State and its citizens on the one side and the Federal Government on the other, the anticipated costs of eradication.

To put this enlarged program into immediate operation, so far as available funds permitted, $2,175,000 of the unexpended balance of the funds appropriated for the fruit fly was reallotted by the Secretary, August 26, and made available for use in the first quarter of the fiscal year 1930. This reallotment left for the last three-quarters of the year an amount sufficient only to carry on those phases of work incident to the closing out of accounts, the protection of Government property and leases, and other similar items which must be provided for. This action seemed to be fully justified by the necessity of increasing the work to the utmost to maintain the eradication feature of the program until the full enlargement contemplated in the plan was provided for. The reallotment will make it possible during the remainder of the first quarter to about double the inspection, clean-up, spraying, and other strictly eradication work, and will also provide for some expansion of the scouting, inspection, and investigational work as well as maintaining the enforcement of the quarantine. It means, however, that unless additional funds are provided the fruit-fly eradication and quarantine work must be largely suspended by October.

The great expenditures which are clearly indicated as necessary to effect

the eradication of the Mediterranean fruit fly present a new outlook in economic or applied entomology. It goes without saying that such expenditures can be justified only under the showing of a reasonable possibility of success. On the other hand, with the assurance of such possibility as confirmed by the committee above referred to and inasmuch as the opportunity is immediate and not continuing, there would seem to be full justification for the expenditures now under consideration. Such costs of eradication must be measured against future and continuing losses to fruit and vegetable crops which may well amount annually to many times such costs.

Recent reports on the clean-up and spraying work being carried out in Florida give great encouragement that the fruit fly can be eradicated. It has already been noted that the inspections throughout the Cotton Belt States have not resulted in the finding of any instance of local infestation of the pest. A similar inspection has been carried out in California to make sure that an invasion of this pest was not building up in that State—also with negative results. In Florida during the last few weeks there has been a rapid diminution in fly abundance and fruit infestation, and there have been few new records of the findings of infested fruit or flies. This does not mean that success is in sight or that it has been almost attained; but it does indicate that, if these means of control can be greatly increased and intensified, eradication is possible. The findings referred to are based on the reports of inspection leaders who are in each county directing labor forces which are collecting and destroying the fruit. Such inspectors therefore have ample opportunity promptly to discover new points of infestation. The notable reduction in fly numbers is also indicated by the negative results during the last six weeks from some 6,000 traps with baits attractive to the fly which have been distributed throughout the eradication area.[1]

RESEARCH

Reference has been made in the foregoing pages to some of the results of the research work of the Bureau of Entomology in cooperation with Plant Quarantine and Control Administration relative to this new fruit and vegetable menace. The Bureau of Entomology, which is charged with the research work on insects of the department, has been unable to finance the great volume of work which the problems of fruit-fly eradication has called for, and this work has been supported very largely out of the special fruit-fly fund. A more complete statement of this cooperative work will be found in the report of the Chief of the Bureau of Entomology. The results so far of this research have been of immediate service (1) in developing a more effective type of poison spray to kill the adult flies in orchards; (2) in developing attractants which make possible the collection of such adult flies in orchards or elsewhere to determine the presence or spread of the pest, and (3) in developing a fumigant with which to kill adult flies in motor and railway cars, buildings, or other premises. In all of these directions great success has been met with, and new or improved means are now being applied daily in the control and eradication work.

Another very important phase of research of immediate and future value is the determination of methods of sterilizing fruit either by refrigeration or heat, referred to in the foregoing discussion—results which will make it possible to utilize all fruit other than that actually infested either in commerce or in some type of processing. Methods have also been devised for the disposal of waste and cull fruit both in bulk from the orchards and as a continuing or daily factor in connection with packing houses. Machinery for this purpose was devised, and methods for bulk disposal were worked out which were immediately put into use and have tremendously facilitated the disposal of the infested fruit of the crop of 1928–29. Of immediate importance also to the campaign of eradication have been the exact determinations made by this unit as to the host relationships of fruits and vegetables in Florida—determinations which have been translated into quarantine restrictions or into release of articles therefrom.

CLEANING OF RAILWAY CARS AND BOATS AT DESTINATION

The cleaning or disinfection, at the point of unloading, of railway cars, boats, and other vehicles or containers

[1] Up to this date (Nov. 2) no findings of infested fruit have been made in Florida since Aug. 27, nor have any flies been taken in traps since Aug. 12.

which have been used in transporting restricted articles from Florida, is required under the fruit-fly regulations.

The movement of refrigerator and ventilated cars containing Florida host fruits and vegetables takes place over practically every railroad operating interstate in this country, and the restricted articles are normally consigned to almost every city and many of the larger towns of the United States. Under the customary procedure which had obtained in the past, refrigerator and ventilated cars had been billed to new loading points and cleaned more or less carefully on the tracks there before being reloaded. In view of the fact that the Florida situation was not fully known and that there was a possibility of such cars containing infested products, such a policy involved a very material danger, especially to the fruit-growing districts of the South and West. Cars loaded in Florida with grapefruit and oranges and unloaded at such points as New York, Philadelphia, Pittsburgh, and Chicago often were found later to be carrying from one to several hundred injured and discarded citrus fruits. If these were infested, the placing of such cars on loading tracks in peach-growing districts and other fruit-producing areas might easily have resulted in the escape of the Mediterranean fruit fly in such areas and eventually in the general establishment of the pest throughout the United States.

The dangers involved in this situation and the quarantine provisions which had been issued in order to meet them, were presented to the railroads in a communication from the administration dated May 8. At the same time, an enforcement organization was placed in the field with three objectives: (1) Notifying freight agents at points of destination of individual cars, by car number, which required cleaning; (2) working out with the railroads arrangements at the larger cities whereby refrigerator and ventilated cars could be cleaned at the destination terminal; and (3) inspection of empty refrigerator cars in transit to determine whether those which had previously been used in carrying Florida products had been properly cleaned before being billed to new loading points.

As the shipment of Florida' host fruits and vegetables to the Southern and Western States was discontinued (PQCA–229) on May 16, the destinations involved throughout the remainder of the spring shipping season were confined to the Northern and Central States. Practically all such north-bound movement passed through the gateways of Potomac Yards, Va., and Cincinnati, Ohio. Inspectors stationed at these points attached car-cleaning instructions to the waybills of all northbound cars carrying Florida products, and at the same time notified the inspectors at the destination freight yards that such cars were en route. Traveling inspectors with headquarters in Boston, New York, Pittsburgh, and Cincinnati-Chicago, respectively, consulted with the railroad officers and freight agents involved to make certain that facilities were available and that the cars were actually being cleaned.

Empty refrigerator cars were inspected in transit at Potomac Yards, Cincinnati, Evansville, St. Louis, and Atlanta, and for briefer periods at Buffalo, Cleveland, Toledo, and Chicago. One hundred and thirty-one cars which bore evidence that they had been used in the transportation of Florida products but had not been cleaned at the unloading point were intercepted between the middle of May and the end of the fiscal year. These were either cleaned at the point of interception or traced and cleaned later. The figure given is in addition to certain cars found dirty by railroad employees themselves and cleaned without reporting the individual numbers of the cars to the department.

Between May 16 and June 30, 4,310 carload shipments of restricted material were reported as consigned from Florida to approximately 190 cities and towns scattered throughout the area into which Florida products were allowed to move. By June 30, car-cleaning reports had been received from the railroad companies covering 4,181 cars; of the balance the railroads are known to have cleaned some about which they failed to make reports, others were overlooked and in many cases discovered later and cleaned in some other area, while still others were in the cleaning yards at the end of the month.

In addition to keeping in touch with the movement of individual cars which left Florida with restricted articles after the quarantine became effective, the administration pointed out to the railroads that the requirements were also applicable to cars which had been used for the transportation of such fruits and vegetables prior to May 1. The damage which might occur from a single infested fruit reaching a fruit-growing area was pointed out to them, and they were urged to take every

precaution to keep "empties" from carrying fruit flies. Most of the railroads and refrigerator-car lines made every attempt to carry out this recommendation, and for a period of several weeks railroad employees at the larger northern cities opened every empty refrigerator or ventilated car in their territory and cleaned all those which showed any signs of having transported Florida articles.

During June Federal inspectors made a survey of the situation in the Pacific Northwest, visiting especially the freight stations at Spokane, Yardley, Hillyard, Walla Walla, Attalia, Seattle, and Auburn, Wash., and Portland, Oreg. No definite and positive violations of the quarantine regulations were observed. It was found, however, that refrigerator cars of unknown prior use were reaching the Pacific Northwest after having been very poorly cleaned or not cleaned at all. The inspectors reported that the cars might have carried many serious pests and that it appeared in general that such cars may be responsible for a considerable amount of the pest dissemination occurring in the United States.

As a result of reports by the administration to the State inspectors of Washington and Oregon on this subject, the State departments concerned have undertaken the inspection of all of the refrigerator cars arriving in their various horticultural districts, and all dirty cars are now being cleaned under the supervision of State employees. No general Federal inspection force was therefore organized for the Pacific Northwest.

Supplemental to the Federal requirements the fumigation of all refrigerator cars from eastern points was insisted on by the officers of the States of Arizona and California, and under these requirements the largest of the refrigerator-car lines, operating in the Southwestern States, reports having fumigated 295 cars with hydrocyanic-acid gas during May, and 1,174 during June.

The conditions observed in refrigerator cars in connection with the enforcement of the car-cleaning requirements of the fruit-fly quarantine strongly indicate the desirability of a general rule on this subject applying to all interstate commerce. The danger that "empties" may be aiding in the distribution of serious insect pests throughout the United States has been strongly emphasized by many instances of such carriage of pests to new locations. The enforcement of a general regulation that all railway cars used for transporting agricultural products shall be cleaned at the point of unloading would have the advantage of disposing of the débris therefrom in large cities where ultimate damage is least likely to occur, whereas the present practice of diverting the empty cars to new loading points before cleaning means that every opportunity is given for the establishment of infestations in districts having large horticultural interests.

GIPSY MOTH AND BROWN-TAIL MOTH

SEVERITY OF GIPSY-MOTH INFESTATION INCREASING IN NEW ENGLAND

The severity of gipsy-moth infestation based on the acreage of defoliated woodland was much greater in the summer of 1928 than it had been for many years. Apparently the acreage for the summer of 1929 will exceed that of the previous year as the pest is unusually abundant in Maine and New Hampshire. The insect has increased during the last few years in eastern Vermont and in Massachusetts west of the Connecticut River, and to a less degree in Connecticut, but in most of this territory the pest has not become abundant enough to defoliate large areas. The fact that this increase has been progressive during the last few years indicates potential damage and additional difficulty in the future in keeping the barrier zone (see p. 11) which adjoins this territory to the west, free from the insect.

These conditions were emphasized during the year by the discovery of an increasing number of infested locations in the barrier zone. In March, 1929, a deficiency item of $50,000 was appropriated by Congress to make possible the clean-up and treatment of infestations that had been discovered earlier in the year. The elimination of such infested areas is vital if the protection of the area west of the barrier zone is to be maintained.

EXTERMINATION WORK IN NEW JERSEY

The effort to eradicate the gipsy moth in New Jersey, which has been going on now since 1920, seems to be fairly rapidly approaching a successful completion, only one infestation, namely, that in Piscataway Township, having been found during the year. Necessarily, however, intensive inspections must be maintained for some years more over a portion of the area. The area where intensive work is now

required covers considerably less than 200 square miles. This area includes the more important centers of infestation, as originally determined. Intensive scouting work was begun in the northern part of this area in December, 1928, and was completed in April, 1929. A tree-by-tree inspection was made of the entire townships of Mendham and Bernard, and the northern part of Hillsboro, together with similar inspection of substantial acreages that were contiguous in the townships of Randolph, Denville, Chester, Hanover, and Morris, but no infestation was found.

At the conclusion of this work a number of inspectors were detailed to examine territory which was under suspicion on account of having been previously infested, and early in May larvæ of the insect were found in Piscataway Township, near the Hillsboro Township line. The center of infestation was in an area used for a dump, and hatched egg clusters were present, indicating that the colony was more than one year old. The infestation and the surrounding territory was immediately treated, and as a precautionary measure an area embracing over 50 acres was thoroughly sprayed.

Surveys were also carried on by expert inspectors early in the fiscal year 1929 around all of the old colony sites in the outside area, and this was supplemented by the use of assembling cages to attract any male moths that might have developed earlier in the season. This plan of scouting had been tried experimentally for a number of years at the gipsy-moth laboratory and had been tested in the field over large areas. The results were sufficient to indicate that it was of value in checking up infestations in suspected places, although further development of the method will make it a more reliable index. Four hundred and twelve cages were used in 19 townships, and no gipsy moths were attracted. This tended to confirm the results of the field scouting as indicating that the infestations had been exterminated.

The results of the year's work will make possible a further reduction in the area requiring intensive scouting, but the exact limits can not be determined until early in the next fiscal year.

In cooperation with the State of New Jersey, this work of eradication is being carried out by the administration under a State quarantine, and to give unit control the State has turned over its personnel and funds to the Federal administration. The object of both State and Federal appropriations has been eradication. Quarantine enforcement has had to do only with shipments of nursery stock and forest products moving from infested areas to points outside.

This is the largest extermination campaign ever attempted on a forest insect of this type, and the excellent progress made is gratifying. The volume of work required has been gradually reduced and the completion of this eradication effort is expected within the next few years.

BARRIER-ZONE PROJECT IN NEW ENGLAND AND NEW YORK

Work on the barrier-zone project during the fiscal year has been continued in cooperation with the Department of Conservation of the State of New York. The work of that department was concentrated in towns directly west of the Massachusetts State line and included the rescouting of the areas surrounding the old colonies in that region and on Long Island

Scouting by the Federal force included an examination of the roadsides and orchards in most of the towns in the New England section of the zone and intensive scouting in Milton, Vt., and around all the old colony sites. Conditions in Vermont and southern Connecticut were more satisfactory than during the previous year, but in the Massachusetts and northern Connecticut area there was a marked increase in the number of infested locations. (Table 1.) This made it necessary to examine more of the heavily wooded areas in this region, and additional infestations were found. Similar results were secured by scouting operations of the State officials in New York. Many of the colonies were small, which indicated that they had recently become established by wind spread of small larvæ from points east of the zone, showing that the maintenance of the zone is menaced by the increasing abundance of the insect in adjoining territory to the east. As the season progressed more small infested locations were found, and in May and June a number of larvæ colonies were located, particularly in towns nearest the eastern border of the barrier zone. The woodlands in the vicinity of all of the colonies discovered during the fiscal year were sprayed.

TABLE 1.—*Gipsy-moth infested locations found in the barrier zone during the fiscal years 1928 and 1929*

State and town	1928		1929			
	Infested locations	Egg clusters found	Infested locations			Egg clusters found
			Egg	Larval[1]	Total	
Vermont:						
Colchester	1	63	0	0	0	0
Essex	1	11	0	0	0	0
Poultney	0	0	1	0	1	17
Massachusetts:						
North Adams	1	2	0	0	0	0
Lee	1	41	1	0	1	2
Tyringham	1	3	1	0	1	61
Monterey	1	11	0	0	0	0
Egremont	2	43	1	0	1	61
Sheffield	2	105	16	2	18	1,473
New Marlboro	3	49	16	2	18	1,855
Sandisfield	5	22	2	10	12	32
Otis	0	0	4	0	4	64
Connecticut:						
Salisbury	1	13	4	0	4	163
North Canaan	1	42	5	0	5	167
Canaan	0	0	2	4	6	81
Norfolk	3	52	7	3	10	135
Goshen	1	883	0	1	1	0
Cornwall	1	148	2	0	2	42
Sharon	2	17	0	0	0	0
Warren	0	0	3	0	3	72
Wallingford	1	3,051	1	0	1	251
Fairfield	0	0	1	0	1	1
New York:						
Petersburg[2]	(3)	(3)	1	0	1	4
Hillsdale	0	0	4	0	4	997
Claverack	1	683	1	0	1	128
Taghkanick	1	110	0	0	0	0
Copake	0	0	4	0	4	212
Ancram	1	493	0	0	0	0
Gallatin	1	246	0	0	0	0
Northeast	(3)	(3)	2	0	2	71
Rosendale	1	18	0	0	0	0

[1] The exact number of larvæ were not recorded at the time infested locations were discovered.
[2] All work in New York State was carried out under the immediate direction of the State conservation department.
[3] No scouting done.

The efficiency of the spraying machines was increased by adopting a method which was tried successfully during the previous fiscal year. The sprayer tanks were divided by a partition into two equal compartments which made it possible to fill one part with water by means of a portable pumper while the spray mixture was being used from the other. This made possible continuous spraying and increased the daily acreage that could be treated about 30 per cent.

The small auto trucks that had previously been equipped with a power take-off were used to great advantage in locations that were inaccessible to heavy equipment and where low pressures were required. During the spraying season a 1½-ton truck that had previously been equipped with a take-off of a new design was operated and gave excellent results. Pressures up to 1,000 pounds were used, and the performance was equal to that attained by our heaviest machines. The additional advantages of light weight, ease of handling, and higher speed on the road makes this sprayer particularly adapted to meet future high-duty spraying requirements.

QUARANTINE AND INSPECTION WORK

The area under quarantine in New England is divided into 27 districts, with an inspector in charge, and additional assistants are provided when heavy shipping demands makes this necessary. During November and December, when Christmas trees are shipped, approximately 100 additional inspectors are required, and during the spring and fall nursery-shipping season, 15 to 20 additional men are required. The infested area in New

Jersey is under State quarantine, and material requiring inspection is certified by men detailed from the Federal force who are conducting exterminative work in cooperation with the State department of agriculture.

On July 1, 1928, a minor change was made in the regulations relating to quarantine No. 45, which permitted shipment of Christmas trees and greens originating in the lightly infested area from points in the generally infested area after proper inspection. This has made the regulation more workable and is a convenience to many shippers.

Shipments requiring inspection may be divided roughly into four classes: Evergreen products, lumber and forest products, nursery stock, and stone and quarry products. Table 2 indicates the volume of these products that were inspected and certified.

TABLE 2.—*Articles certified under gipsy-moth quarantine, year ended June 30, 1929*

Article	Carloads	Truckloads	Bags	Barrels and boxes	Bales and bundles	Crates and cases	Pieces	Packages	Lots	Infested				Egg clusters	Larvae and pupae
										Barges	Carloads	Pieces	Lots		
Evergreen materials:															
Balsam twigs			157												
Boughs	65	55	5	5	74										
Boxwood				2				5							
Christmas trees	724	102		1	185		[1] 460								
Cut cedars	3				29		[1] 25								
Laurel		7	985	230	10, 149			5							
Mixed greens		1	23	2, 296	19			198							
Wreaths			8	260	2			10							
Total	792	165	1, 178	2, 794	10, 458		[1] 485	218							
Nursery stock	325	1, 432		12, 827	6, 831	4, 607		10, 397							
Forest products:															
Barrel parts	19				810				5						
Crates and cratings		1			9		332		2			2		5	
Fuel wood	219	17		12					[2]						
Logs	1, 527	2				1	46		3						
Lumber	1, 029	98				21			144		19		2	342	224
Piles and poles	446	29					4, 415		3			16		16	
Posts	9	9					311								
Pulp wood	2, 706														
Reels	314						5, 555				4			21	2
Shavings	124	3													
Ship knees	24						681		2						
Spool stock	173														
Ties	2, 446										36			468	45
Vine and shrub cuttings				67	2	59									
Miscellaneous	[3] 92	15	93	20	356	21	526		18	3	3			167	
Total	[3] 9, 128	174	93	99	1, 177	102	11, 866		[2] 177	3	62	18	2	1, 019	271
Quarry products:															
Crushed rock	3, 097	30													
Curbing	275						20								
Feldspar	189		2				122								
Garnet	19														
Granite	[4] 7, 697	4				428	175, 584				61			[5] 126	7
Grout	268														
Marble	1, 953			36, 768		58, 221	9, 155								
Old iron	30										1				8
Paving	[4] 399										35			356	46
Miscellaneous	9	10	1			15	8								
Total	[4] 13, 936	44	3	36, 768		58, 664	184, 889				97			482	61

[1] Trees.
[2] In addition to 188 cords of fuel wood.
[3] In addition to 4 barges.
[4] In addition to 39 barges of granite and 6 barges of paving.
[5] This includes 42 egg clusters found on carting materials which could not be assigned to any one shipment.

Owing to the increase in density of infestation in the generally infested area, extreme care was exercised in the examination of products offered for shipment, which rendered the cost of operation somewhat higher than during the previous year. The conditions also made clear the importance of examining tourists' camps so far as time would permit. During the year 116 tourist camp sites were inspected, 15 of which were found infested with the gipsy moth and were cleaned up by the owners or the town officials.

THE BROWN-TAIL MOTH

The brown-tail moth, which at the beginning vied with the gipsy moth in importance of injuries occasioned and exceeded it perhaps in the annoyance which followed its presence, due to the irritating or stinging quality of the larval hairs, has for a considerable period decreased in numbers to such an extent as to have lost much of its early importance and interest. The decrease in numbers may be explained to some extent by the clean-up of winter webs which is easily possible with this insect, but it seems to be largely due to control by natural means such as disease and parasitic enemies, many of which latter have been introduced from Europe.

During the last two years, however, this insect has been increasing in numbers in many sections in southern Maine, New Hampshire, and eastern Massachusetts, particularly where no attempt had been made to remove the winter webs or carry out spraying of trees in early summer, and considerable defoliation has resulted.

The area under quarantine on account of the brown-tail moth has not been changed and is administered in connection with the enforcement of the gipsy-moth quarantine. It may be possible later on, when funds are available to scout more intensively the area now included in this quarantine, to reduce the area to a considerable extent. Inasmuch, however, as this area is entirely within the gipsy-moth area and the restrictions are similar to those imposed for the latter insect, the quarantine is not particularly burdensome either to the citizens or as to cost of administration.

THE SATIN MOTH

The satin moth will be recalled as a specific enemy, imported from Europe, of poplar and willow trees. It is now known to occur both in New England and in the State of Washington. In New England it is entirely included within the gipsy-moth area, and the quarantine is being enforced under the gipsy-moth administration.

During the summer of 1928 an effort was made to determine whether this pest had spread beyond the area previously known to be infested in New England. This survey, cooperated in by the States concerned, has shown that this insect has greatly extended its range. The satin-moth quarantine (No. 53) was, therefore, amended to cover the newly infested territory, which included 21 towns in Maine, 51 in New Hampshire, 8 in Vermont, 33 in Massachusetts, and 59 in Connecticut, a total of 172 towns containing approximately 5,116 square miles.

In the State of Washington the pest is still limited to the counties west of the Cascade Mountains, but the intensity of infestation is gradually increasing, and the insect is slowly spreading southward. The shipment of poplar or willow trees from the areas covered by the quarantine regulations is prohibited.

EUROPEAN CORN-BORER CONTROL

GENERAL STATUS

This report is made too early to give more than an indication of the corn-borer developments as affecting the crop of 1929, but the records so far secured indicate a more or less general increase. Whether this is a mere fluctuation such as has been experienced in past years or a decided advance remains to be determined.

In connection with the crop year 1928, practically no commercial damage was experienced other than in a small area in Rhode Island and Massachusetts. This area involved only a few townships in which, largely by reason of neglect of clean-up or other controls, the corn borer had increased to such an extent as to produce serious local crop losses. In the nearest approach to the Corn Belt, namely, in western New York, Pennsylvania, Ohio, Indiana, and Michigan, the corn-borer population averages less than 7 borers to 100 stalks. This represents an actual decrease from the 1927 average of 10 borers per 100 stalks. The decrease is clearly due to effectual clean-up operations in the more heavily infested strip bordering Lake Erie and in eastern Michigan which overbalanced the modest increase in the more sparsely infested area in these States; in much of this area

there is still less than 1 borer to 100 stalks of corn. The question which can not now be answered is how rapidly and how much the corn borer will build up throughout the western area in future years. With minor exceptions the normal spread by flight in the New England area and in the western area has been in line with that of previous years.

SINGLE AND MULTIPLE GENERATION STRAINS

An interesting minor development is the continued movement of the 1-generation strain from the original eastern New York infestation into New Hampshire and Connecticut and the extension of the previously infested areas in Vermont, Massachusetts, and eastern Pennsylvania.

Both the 1 and 2 generation strains of the European corn borer were found on Long Island in separate areas during the 1928 season. The 1-generation area is on the western end, in Kings, Queens, and Nassau Counties, while the 2-generation area is on the extreme eastern end of Long Island. In the 1-generation area the infestation was found not to extend east of Nassau County and the 2-generation area did not extend west of the Mattituck Inlet, in Southold Town, nor west of the Schinncock Canal, in Southampton Town. This leaves a strip of noninfested territory between the 1 and 2 generation areas on Long Island.

With respect to these "strains," the peculiar biological fact in the history of the corn borer will be recalled, namely, that the New England infestation is two or more brooded, whereas the infestation which was established about the same time, with the original introduction of this pest with broomcorn from Europe, in eastern and western New York and in Ontario, Canada, is a 1-generation strain, and apparently holds to that biological peculiarity with great tenacity, as shown by transfer experiments. Potentially a 1-generation strain should be very much less of a menace than a strain the generations of which are restricted only by length of the season. The spread west from the New England area, therefore, of the 2-generation strain is one which may very well increase the risk from this pest. On the other hand, the movement eastward of the 1-generation strain may, by interbreeding, counteract to some extent the tendency to multiple generations in the eastern strain of the corn borer. However, the result may be unfavorable in that it may introduce a strain that will come in between the broods of the other and thus give three broods to contend with in New England instead of two.

The results of scouting during the 1928 season are given in Table 3.

TABLE 3.—*European corn-borer infestation record, 1928*

State	Townships found infested	Townships found not infested	Area under quarantine at end of the 1928 scouting season	
			One-generation area	Two-generation area
	Number	*Number*	*Square miles*	*Square miles*
Conn.	24	90	42.73	1,008.88
Maryland		29		
Mass.	40	74	2,243.25	4,567.92
N. H.	10	48	128.00	4,659.00
New Jersey	4	168	71.29	
Pa.	13	180	27,554.35	
Vermont	102	93	4,912.90	
Maine	4	22		1,680.62
Indiana	54	102	10,340.00	
Ohio	98	115	28,424.00	
Michigan	97	127	57,980.00	
W. Va.	7	19	516.00	
Illinois		102		
Wisconsin		59		
New York			49,196.00	8.00
R. I.				1,248.00

Of interest also is the fact that the four isolated points of infestation in Connecticut—Oxford, Milford, New Haven, and Bridgeport—discovered prior to 1928 and thoroughly cleaned up by intensification of the ordinary farm practices of removing corn remnants, plowing, etc., were not infested in 1928 so far as could be determined by careful inspection. A similar cleanup and elimination in the case of three isolated points in New Jersey—Bayonne, Jersey City, and Woodbridge—may also be recorded. On the other hand, two localities in Connecticut—Old Saybrook in Middlesex County and Old Lyme in New London County—similarly cleaned up, were reinfested in 1928 and this was true also of three townships in Vermont—Pawlet, Ludlow, and Plymouth. For similar eradication work in 1929 see page 17.

DETERMINATION OF INCREASE OR DECREASE OF INFESTATION

Fairly intensive inspections are conducted each year, in the latter part of the season, to determine the actual increases or decreases in the corn-borer infestation throughout the area, east

and west. In the interest of accuracy and elimination of any special selection, as nearly as possible representative fields as to area and cultivation are chosen, five to each township, one in the center and the other four in the approximate center of the four quarters of the township. In each of these fields 500 plants are examined, taken respectively 100 plants near the center of the central row of the field and similarly 100 plants from each quarter of the field, all of the plants at each of these five points being taken in sequence. Fields as nearly as possible in the same general location are taken year after year, but the same field very often is not available. The results of this survey for the crop year 1928 are shown in Table 4.

TABLE 4.—*Infestation survey of European corn borer, 1928*

State	Townships examined	Fields examined	Acres examined	Plants infested	Average larvæ per infested plant	Total larvæ per 100 plants
	Number	*Number*	*Number*	*Per cent*	*Number*	*Number*
Connecticut	15	54	2.631	2.90	1.68	4.87
Maine	10	42	5.075	2.38	1.12	2.65
Massachusetts	192	857	372.615	29.74	4.61	137.22
New Hampshire	43	181	44.092	2.05	1.65	3.40
Rhode Island	34	137	51.172	44.22	5.69	251.71
Eastern New York	116	570	1,981.632	9.02	1.62	14.60
Western New York	400	1,962	6,637.26	2.88	1.83	5.26
Michigan	348	1,737	12,186.23	5.07	2.21	11.22
Indiana	61	305	3,358.70	.20	1.72	.35
Ohio	496	2,480	20,393.64	3.07	2.11	6.49
Pennsylvania	206	1,025	3,193.95	.45	1.81	.82
Total	1,921	9,350	48,226.997			

With respect to this table it should be noted that the high average for 100 plants for Rhode Island and Massachusetts is due to the very intensive infestation in a few townships in adjoining portions of these States, and that, eliminating these townships, the average for all of New England would be very low—not even approaching commercial loss. For the purpose of comparison, it will be recalled that commercial damage begins with about 500 larvæ per 100 plants.

DIRECT COMPARISON OF TOWNSHIPS SURVEYED IN 1927 WITH THE SAME TOWNSHIPS SURVEYED IN 1928

Data from 1,101 townships surveyed in 1927 compared with the same townships surveyed in 1928 show a reduction in the average number of borers per 100 plants in Michigan from 26.06 to 15.39. The greatest improvement in the heavily infested counties is that shown in St. Clair, where there was a reduction from 113.44 to 42.09, and in Wayne County, where there was a reduction from 91.42 to 14.35.

In Pennsylvania there was a reduction in the number of borers per 100 plants from 10.51 to 1.22. This reduction is due largely to conditions in Erie County, there being 40.38 borers per 100 plants in 1927 as compared with 6.47 in 1928.

In Ohio there was an increase in the number of borers per 100 plants from 3.79 in 1927 to 8.23 in 1928. The most heavily infested county in Ohio in 1928 was Ottawa, where the average number of borers per 100 plants increased from 33.56 in 1927 to 76.61 in 1928. Allen Township in Ottawa County showed 187.26 borers per 100 plants in 1928, and is the most heavily infested township in the 1-generation area. In Lucas County, which was the only county in Ohio where compulsory clean-up regulations were enforced during 1928, there was an increase from 31.64 to 33.25.

ERADICATION OF OUTLYING INFESTATIONS

Thirteen European corn-borer infestations were found in Brooklyn, N. Y., during the 1928 season, and 18 European corn-borer specimens were collected. It was deemed desirable to do burning work in this section, and that was begun March 12, 1929, but because of the adverse weather conditions it was not completed until April 27. Two hundred and fifty vacant-lot weed areas and back-yard gardens, or

244 acres, were burned with 37,100 gallons of furnace oil.

But one borer was found on Staten Island during the season of 1928. Burning work in this section was started on April 1, 1929. In all 55 vacant lots and small back-yard gardens, or approximately 18½ acres, were burned with 2,500 gallons of furnace oil. This work was completed April 8. During the period in which the work was being carried on the climatic conditions were very unfavorable, and long delays were caused by rainy weather.

Three townships and one borough were found infested in New Jersey during the season of 1928; namely, Rivervale Township, Bergen County; North Brunswick Township, Middlesex County; Madison Borough, Morris County; and White Township, Warren County. These areas were burned over with fuel oil and not placed under quarantine. In some cases the cover crop was too heavy and pick-up work was necessary. Stalks and stubble were pulled and placed in piles and disposed of by the use of hand burners. The clean-up in Madison Borough was taken care of by the owner. In the three townships named 73 acres were burned, 7,900 gallons of fuel oil being used in the work.

In addition to the townships which were found infested in Pennsylvania during the season of 1928 and which were added to the Federal quarantine, there were four townships found infested which were not added to the quarantine. These were East Allen, Lower Nazareth, Palmer, and Lower Mount Bethel in Northampton County.

To add these four townships to the regulated area would have necessitated more quarantine stations and consequently large expenditures. Therefore, through an arrangement made with the State department of agriculture, these four townships were not added to the quarantined area but were cleaned up by the State. The State appointed an inspector in each of the four townships to work in cooperation with the county agent in that county in carrying on as thorough a voluntary clean-up as possible. The State could not consider making such a clean-up compulsory.

There were 3,915 acres of corn in the Pennsylvania areas, and 86.7 per cent of the farms passed the final inspection as having completed the clean-up work satisfactorily.

CLEAN-UP WORK IN NEW ENGLAND

During January, February, March, and April, 1929, several Federal inspectors assisted the State of Massachusetts in looking up small back-yard gardens and small lots of corn within the residential sections of the eastern part of that State. Previously the State had not attempted to reach the small gardener, but had sent its notices to the farmers. During this cooperative work, some 2,000 back-yard gardens were found where clean-up work had not been properly done or no attempt had been made to do it. The owners were notified that it was necessary for them to clean up as soon as possible, and their names were submitted to the State department of agriculture. Almost 100 per cent cooperation was received from the owners of these small back-yard gardens and it was not necessary to prosecute any of them. The larger growers of corn were less careful and if the corn borer is to be brought under such control in Massachusetts that sweet corn is to be raised profitably much closer attention to clean-up work will have to be given by the producers.

The State of Rhode Island upon the passage of its compulsory law early in 1929 made an attempt to clean up in the northeastern section of the State, where the infestation of the borer was most severe last year. Some good was accomplished, but since the work was not started until April 15 the results were unsatisfactory. Connecticut also did some clean-up work in its infested area, and it is expected that compulsory clean-up regulations will be enforced in these two States this fall and winter.

QUARANTINE AMENDED TO PROTECT MAINE

The degree of infestation in the corn-borer extension into the southwestern part of Maine has been very light, largely due to active clean-up operations instituted by the growers. On the other hand, as already indicated (p. 16), the borer infestation in a fairly important green-corn-producing section of Rhode Island, with a slight extension into Massachusetts, was very heavy and corn shipped into the Boston market from this area was so badly infested that it was almost impossible to find an ear of corn without borers. Wholesale shipments of such infested

corn to Portland, Me., caused considerable alarm among Maine farmers, and it was feared that the number of borers introduced with it would counteract the results of the clean-up efforts. At the request of the Maine commissioner of agriculture, the Federal quarantine was amended on August 7, 1928, by adding the requirement that restricted articles will not be allowed to be moved into the State of Maine from any point in the regulated areas outside that State unless a certificate or permit therefor shall have been issued by the United States Department of Agriculture. To enforce this restriction five quarantine stations were maintained on the principal bridges between the States of Maine and New Hampshire. The period of operation was from August 8 to September 11, 1928. During this time 256,516 cars were stopped and 7,286 ears of corn taken. In addition to the corn, there were seized at these stations quantities of uncertified rhubarb, beans, celery, beets, gladiolus blossoms, dahlias, asters, zinnias, chrysanthemums, cosmos, and mixed flowers.

USE OF STUBBLE PULVERIZERS

To aid in the clean-up of corn stubble prior to the planting of small grain, and under special authorization and appropriation, stubble pulverizers purchased during the clean-up campaign of 1927 were loaned to farmers under a cooperative agreement. According to the original plan these machines were to be used in the 1 per cent areas of Ohio, Michigan, and Indiana and, also, if there was sufficient demand, in Pennsylvania and New York. Little wheat and oats are sown in Pennsylvania and New York, while large wheat areas are found in the northern part of Ohio. About the first week in October, information relative to the department's plan was given to the farmers through agricultural organizations and the press. As most of the winter wheat had already been sown and many farmers did not care to operate equipment in fields on account of the ground being loose and unsettled, there was less demand for the equipment than had been anticipated.

Sixty-one machines were asked for, and these were used on 211 farms in Ohio and Michigan, a total of 4,338 acres being cared for. The average cost to the farmers was 60 cents per acre.

ROAD-STATION MAINTENANCE

In the western area, the States west of Pennsylvania, the quarantine-line work started about July 20 and was discontinued September 30, 1928. In the central area, or the 1-generation area east of Ohio, the stations were started July 22 and were discontinued October 30.

The stopping and searching of cars for corn as they left the quarantined area is believed to have been done in a more efficient and thorough manner than ever before.

The number of cars refusing to stop during the 1928 season might well be considered negligible. For instance, in Ohio, Michigan, and Indiana, only 995 cars refused to stop as compared with more than 4,000,000 which stopped and were inspected.

Of the corn seized at the quarantine lines, but a small portion could be examined. Out of 612 shipments 632 borers were obtained. Some of the corn taken at the lines was destined to States far outside of the quarantined area, such as Nebraska, Missouri, Texas, and California. Two borers were found in one shipment consigned to Reynolds, Nebr., and one borer was found in a shipment intended for St. Louis, Mo. Three infested ears were being taken to Rochester, Minn.

GRAIN INSPECTION IN THE CENTRAL AND WESTERN AREAS

On March 1, 1929, the Federal regulations were amended discontinuing the requirement of certification of packages of shelled corn weighing 2 pounds or less. This eliminated a great deal of trouble and the department was able to carry on the work with a smaller force than previously.

The practice of issuing permits to grain dealers is still being followed. These permits are granted to dealers who sign and file with the Department of Agriculture an agreement not to move or allow to be moved to points outside the quarantined area under certificates issued to them, any corn until it has been shelled and cleaned to comply with Federal regulations. All elevators making regular shipments of shelled corn are using the permit system, and inspectors issue permits and certificates sufficient to carry them for 30 days. Periodic inspections are made of the corn and equipment at the elevators. There are a number of grain elevators that do

not ship out of the quarantined area regularly and in these cases inspection and certification of individual shipments is necessary.

MARKET INSPECTIONS IN NEW ENGLAND

The quarantine in New England on vegetables is effective only from June 1 to December 31 of each year. On other products, such as corn and flowers, it is effective the entire year. Inspections of such materials are made at Boston and Worcester, Mass., Providence, R. I., and Portland, Me. During the calendar year 1928 the following products were permitted or certified:

Certified	3,932,992 cut flowers and plants.
Do	34,112 bushels of vegetables.
Permitted	65,511 bushels of vegetables.
Do	25,820 shipments of oats and rye straw.
Do	7,621,391 pounds of seed, commercial, popcorn, and broomcorn.
Certified	14,730 pounds of seed, commercial, popcorn, and broomcorn.
Permitted	44,052 pounds shelled corn shipped under the permit system.
Do	48 bales of corn husks and 1 bunch Sudan grass.

The articles certified originated in the regulated area and those permitted originated outside and were reshipped from points within. In these inspections 4,109 specimens of the European corn borer were collected. There seems to have been a rather heavier infestation in certain vegetables and in certain ornamentals than usual. For example, as many as 365 borers were taken from 1 bushel of Lima beans, and gladiolus flowers were frequently infested.

JAPANESE BEETLE

SPREAD AND QUARANTINE ADJUSTMENT

The area now under regulation on account of the Japanese beetle involves portions of seven States and the District of Columbia; namely, in addition to the latter, all of New Jersey, eastern Pennsylvania, northern Delaware, and small portions of Connecticut, New York, Maryland, and Virginia. This area now reaches a total of 21,353 square miles as compared with 19,827 square miles of the previous season—an increase of 8 per cent. The most distant point of spread is approximately 192 miles by air line from the original center in western New Jersey. The main area of this spread has been very largely occasioned by the normal annual flight outward of the beetles of some 10 to 15 miles during the period of 18 years since the original introduction of the insect—making allowance for the much slower spread in the years immediately following its introduction. A type of aided spread to isolated points remote from the general area is discussed below.

During the summer of 1928, Japanese beetles were found at the following new localities all more or less isolated from previously known infestations: Hagerstown, Frederick, and Delmar, Md.; Lewistown and Sayre, Pa.; Hartford and New London, Conn.; Springfield, Mass.; several points in Delaware; and in and near Alexandria, Va. In addition, the isolated infestations formerly known and made the subject of partial eradication experiments in northern Delaware and at Baltimore, Cambridge, Perryville, and Chesapeake City, Md., and Washington, D. C., were found to be persisting. No Japanese beetles, however, were discovered at York or Gettysburg, Pa., or Ridgely, Md., where eradication work had also been carried on.

In consideration of this situation a public hearing was held September 24, 1928, "to consider the advisability of extending the Japanese-beetle quarantine to the States of Massachusetts and Virginia." At this hearing also, and in a series of subsequent conferences, the subject of what disposition should be made of such outlying points as those referred to above was given consideration.

The quarantine as later issued included the area covered by the normal or contiguous spread of the insect, namely, for Pennsylvania the township of Rye in Perry County; for Connecticut the city of New Haven and certain adjacent townships; for Delaware all of the State north of Sussex County; and for Maryland the northeast corner of the State, including most of Cecil County. With respect to the isolated points the Secretary approved the policy of treating them as separate control units rather than including them by a broad extension of the quarantine lines in the general quarantined area. This action was conditioned upon cooperation by the States concerned acceptable to the department, and is in accord with policies which hitherto have been followed in connection with other plant quarantines. In the case of the Japanese beetle such State cooperation involves

(1) nursery control under State quarantine, but with Federal supervision, making such control equivalent to what it would be under a Federal quarantine; (2) enforcement of clean-up operations to reduce or, if possible at certain points, to eradicate the pest—these operations to include soil treatment of areas known or believed to be infested with larvæ and the collection of beetles during the next summer by use of traps or by hand.

The outlying points of infestation concerned are as follows: Hagerstown, Frederick, Cambridge, and Delmar, Md.—the latter town lying in both Maryland and Delaware; Lewistown and Sayre, Pa.; Hartford and New London, Conn.; Springfield, Mass., and Washington, D. C., including Arlington County, Va., namely, the portion of Virginia which was originally incorporated in the District of Columbia.

At several of these points only one or two beetles have been found, very possibly mere chance escapes from passing motor cars. Such points and the number of beetles found in each are as follows: Hagerstown, 1 beetle; Frederick, 2; and Lewistown, 1. In Cambridge, 15 beetles were found; in Sayre, 14; in New London, 11; and in Hartford, 12. At none of these towns has there been any determination of soil infestation, but the numbers of beetles would indicate that the soil may be infested.

The points where definite soil infestation has resulted include, notably, Washington, Baltimore, and Springfield, and, to a less extent, Cambridge and Delmar, but at all these points the beetles are limited to the town or immediate suburbs. At Springfield a heavy infestation developed, limited practically to two small points, in which by intensive collection, over 5,000 beetles were taken. At none of these points are any nurseries directly concerned or areas of production or distribution of farm produce. Nevertheless, any nursery establishments in proximity to the towns enumerated will be brought under the same restrictions that are now applied to nurseries in similar situations in the general Japanese-beetle area.

The proposed controls against spread from such outlying points may be even more effective than the controls in the general area under the Japanese beetle quarantine, particularly as it is proposed to collect and destroy the beetles as they emerge throughout the season. The continuance of this arrangement beyond 1929 will necessarily be conditioned upon the success of the local control efforts and the spread, if any, into intervening territory.

Such outlying infestations must necessarily be a recurring factor in connection with all plant quarantines, and, in the case of the Japanese beetle, the plan for 1929 will give opportunity for a thorough demonstration of the possibility of control by local clean-up. On the other hand, to include these points and the intermediate territory under the general quarantine would immediately open extensive areas in the States concerned to the uncontrolled movement of nursery stock and farm products, with the probable result of establishing the beetle more or less throughout such areas. It would, at the same time, discourage any clean-up operations in such isolated points, and the result would be the building up of the beetle population at these points and greatly increasing the risk from them as centers of spread by road and rail traffic.

Under the policy which is adopted the benefit of active cooperation by the States, towns, and individuals concerned is secured, and of the enforcement of a clean-up program which will greatly reduce the numbers of the beetles and practically eliminate the very kind of spread, by road and rail traffic, which it is impossible to control with any large measure of success under quarantine.

SPREAD OF 1929

The Japanese beetle record for the season of 1929, so far as disclosed, indicates the following new outlying points: Boston, Mass.; Providence, R. I.; and Norfolk and Cape Charles, Va. The spread of the beetle to such isolated points as those mentioned seems to have had little or no connection with the movement of restricted products but is apparently due to another type of movement which it seems impracticable to attempt to control, namely, accidental carriage of beetles picked up by automobile or train movement through the Japanese beetle area during the period of great beetle abundance. There should be included in such movement also the carriage of beetles in boats moving from Philadelphia, especially during the active beetle season, when, due to what appears to be occasional migratory flight, the air over the Delaware River is filled with flying beetles. Such boat movement would seem to account for some or all of the new outlying points of infestation determined during the present year.

TRAP CONTROL

A very interesting phase of the work of the present season has been the effort greatly to reduce the increase in 1929 in the isolated points found to be infested in 1928, or possibly to eradicate the insect by the use of Japanese beetle traps distributed at such points. The research work of the Bureau of Entomology over a number of years has resulted in the determination that geraniol, a derivative of the Geranium, is a very powerful attractant for the Japanese beetle and in a large degree selective in that it does not attract other insects. The bureau experts have also devised a number of forms of Japanese beetle traps in which this attractant, now synthetically produced, can be placed and beetles collected. The advantage of this comes in making such collections as promptly as possible after beetle emergence and before they have placed their eggs in the soil for the succeeding generation.

An interesting experiment to test the efficiency of such traps was conducted during the season of 1929. Some 500 traps were placed on an estate in a heavily infested district near Roxborough, Pa. The record of collections in these traps during the period between July 11 and August 23 gives a total of 1,874½ pounds, the daily collections ranging from 197½ pounds to 20 pounds—the latter near the close of the period. This represents the collection of nearly a ton of beetles and at the determined average of 4,000 beetles to the pound represents nearly 7,500,000 beetles.

The traps and geraniol were furnished by the department. The cost of installation was $30, of collecting the beetles $225, and of removal and storage of the traps $25, or a total of $280, not counting the traps or chemical. A great many types of traps are now available at prices ranging from 50 cents or less upward, depending on the character and size of the trap.

In heavily infested areas, however, such trapping is not necessarily beneficial unless it is practiced by owners of all infested properties. Otherwise the beetles are attracted in vast numbers to the property in which the traps are placed, and it becomes a concentration point with the possibility of actual local increase of damage, although doubtless of some benefit to the district as a whole. The beetles fly toward the odor; in other words, against the wind, and while definite determination has not been made, are supposed to come from a distance of 1 to 2 miles. In the instance cited the beetles were collected daily.

As already noted, such traps were utilized as one of the main features of the control of the beetle during the season of 1929 in the isolated points of infestation of 1928. In these instances the risk of attracting the beetles from the outside was absent and the total trap collections were so much to the good in reduction of beetles and prevention of the local multiplication and of spread. Some 18,000 such traps were purchased during the spring of 1929 and arrangements made during the latter part of May for their distribution, baiting, and tending. At the close of the fiscal year traps were in operation at the sites of last year's infestations at Alexandria, Va.; Washington, D. C.; Baltimore, Hagerstown, Frederick, Cambridge, Delmar, Chesapeake City, Elkton, Perryville, and Perry Point, Md.; Gettysburg, York, Lewistown, and Sayre, Pa.; Delmar, Del.; Springfield and Boston, Mass.; and Hartford and New London, Conn. Japanese beetles had been trapped in all these localities except Frederick, Md., and Sayre, Pa., by the middle of July, 1929. Necessarily the work of this season is experimental, and the reduction of future Japanese beetle population will be in direct proportion to the efficiency of the method.[1]

NURSERY CLASSIFICATION

As a result of field scouting in nurseries, greenhouses, and premises adjacent thereto during the summer field-scouting season of 1928, and the grub-scouting season in the fall of 1928 and spring of 1929, 28 establishments in which Japanese beetles had

[1] The number of Japanese beetles collected in or in connection with traps during the season of 1929, inclusive, at the points named, was as follows: Delaware—Delmar, 1,034; District of Columbia—Washington, 3,085; Connecticut—Hartford, 882; New London, 168; Massachusetts—Boston, 179; Springfield, 1,064; Maryland — Baltimore, 7,184; Cambridge, 913; Chesapeake City, 1,584; Chestertown, 7; Delmar, 633; Elkton, 834; Hagerstown, 46; Perry Point, 28; Perryville, 825; Pennsylvania—Gettysburg, 270; Lewistown, 1; Sayre, 252; York, 10; Virginia- -Alexandria, 3,940. More than half of the beetles enumerated were actually found in the traps, but at many, if not most points, where the traps were stationed, almost as many more had been attracted to the point by the geraniol but had not yet entered the traps. These were also collected and destroyed by the inspectors and were recorded in the total number for each place or area of distribution. It should be noted that the District of Columbia and Alexandria, Va., collections are part of one area of infestation, giving a total for this area of 7,025.

not previously been discovered were found to be infested.

Administrative instructions issued on February 21, 1929, modified the former classification requirements to permit the subdivision, for classification purposes, of nursery properties under single ownership or management but composed of separate premises. Under these instructions, such parcels may now be independently classified either in Class II or Class III. In addition, unit nursery properties of recent or scanty infestation which theretofore had been designated as in Class III could be subdivided and given Class II or Class III ratings, provided the subdivision containing the infestation was clearly marked by permanent boundaries approximately 500 feet beyond the infested point.

CERTIFICATION OF NURSERY AND ORNAMENTAL STOCK AND FARM PRODUCTS [2]

A total of 73,117,062 plants were certified for movement to points outside the regulated areas. Of these, 7,415 plants were treated with carbon disulphide, 26 with wormseed oil, and 48,558 with hot water. Similarly 15,550 boxes of cut flowers, 15,850.5 carloads of sand, soil, and earth, 465.25 carloads of peat, 1,018 carloads of compost and manure, 7,165,070 packages of fruits and vegetables, and 34,992.5 bales of hay and straw from the regulated areas were certified for shipment. The details of this work by months are published in the Service and Regulatory Announcements of the administration.

Under the regulations effective February 15, 1929, cut flowers and portions of plants without roots and incapable of propagation (such as branches and twigs of trees and shrubs, Christmas trees, holly, laurel, sphagnum moss, and dried portions of plants free from soil) are exempted from restriction, except during the period June 15 to October 15. This latter provision eliminates from the certification requirements a considerable quantity of articles which experience had proved are not subject to infestation except during the period of activity of the adult beetle.

The presence of large numbers of Japanese beetles on the wing in the market and river-front districts of Philadelphia during parts of July and August, 1928, necessitated the curtailment of inspection and certification of farm products. Arrangements were made whereby inspection service was granted only between the hours of 8 p. m. and 10 a. m. Between these hours beetles were not in flight and inspections could be made without danger of reinfestation. This curtailed inspection service was maintained from July 18 until August 23, at which time the beetle flight had decreased to such an extent that the restoration of 24-hour inspection service was justified.

TRANSIT INSPECTION IN PHILADELPHIA AND NEW YORK CITY

Postal and express inspectors were maintained throughout the year in the offices of various common carriers at Philadelphia and New York. In Philadelphia, one transit inspector was stationed during the 12-month period at the platform of the Railway Express Agency (Inc.) at Eighteenth and Market Streets. From July, 1928, to January, 1929, inclusive, two transit inspectors covered the railway mail terminal at Twenty-fourth and Market Streets and visited other mail-distribution points throughout Philadelphia. For the balance of the fiscal year a single inspector was assigned to this postal-inspection work.

During the peak of the fall-shipping season, 11 transit inspectors were stationed at postal and express terminal points in New York City. One inspector covered the express platform at the Grand Central terminal from July to January and was later transferred for the balance of the period to the New York Central and New York, New Haven and Hartford express terminal, to which point the express facilities had been removed from the Grand Central terminal. A single inspector was assigned to the express terminal at Long Island City during the year. Starting in October, an inspector was stationed in the general post office, and from November to April was assisted by an additional inspector. Parcel-post inspection was performed by one transit inspector at the City Hall post office, from November to April, inclusive. Postal inspection at the Grand Central railway mail terminal was performed by three inspectors from November to February, and two inspectors continued during March and April. A single supervisor covered all terminal inspection points in New York City during January and February.

The number of violations intercepted at the transit inspection points is

[2] The following discussion of certification, transit inspection, and road patrol, covers both the Japanese beetle and the Asiatic beetle.

shown below under the heading "Quarantine Violations."

ROAD PATROL

Thirty-five road-inspection points were maintained during August, 32 of which had been established in July. Twenty-two posts continued operations during September.

On all roads on which the volume of traffic warranted, 24-hour inspection services were maintained. On roads of lesser importance men were stationed during the hours of greatest travel, or the hours were staggered so that the inspectors might be at the posts at various times and the traffic could not anticipate a period when inspectors would not be on duty.

Of the cars passing the road stations in 1928, 39,925 were found to be carrying restricted articles. In about 2 per cent of these cases the articles had not been certified, and such articles were either confiscated by the inspectors in accordance with the plant quarantine act or taken back into the regulated area by the owners.

QUARANTINE VIOLATIONS

A total of 588 shipments were intercepted during the year while en route in apparent violation of the Federal or State quarantine regulations. In the majority of cases, the return of the uncertified material to the shipper was effected. A few of the shipments were permitted to proceed, and in a number of instances the contraband material was destroyed. In every case where practicable an investigation was made by an inspector, which included an interview with the shipper and the agent of the common carrier. Of the uncertified shipments, 428 were intercepted in the mails, 106 while being transported by the Railway Express Agency, 23 aboard steamship, 19 at road-inspection points, 8 shipments sent by freight, and 4 at port-inspection points.

Letters were addressed by the administration to a number of violators warning them of the possible consequences of further violations.

Prosecutions were instituted for two Federal violations which occurred during the year. Six cases of Federal prosecutions were closed during the period, the fines imposed totaling $256. Six violators of the Delaware State quarantine were successfully prosecuted under the State law, and fines totaling $90 and costs collected.

THE ASIATIC BEETLES

Following the hearing of September 24, 1928, a quarantine was promulgated (March 2, 1929) on account of the so-called Asiatic beetles, applying to the States of Connecticut, New Jersey, New York, Pennsylvania, and Virginia, and the District of Columbia. The subjects of this quarantine are two species of beetles introduced from Japan with shipments of nursery stock with soil. These beetles have been designated as the Asiatic beetle (*Anomala orientalis* Waterhouse) and the Asiatic garden beetle (*Aserica castanea* Arrow). Judging from the records of plant importations, the former was probably introduced about 1900 with large importations of nursery stock made by a nursery then existing at New Haven, Conn., and the spread in the United States seems to have resulted from this source, although obviously there may have been other importations about the same period or later. The time and place of introduction of the other species is not so definitely indicated, but was doubtless by similar importation of nursery stock with soil, possibly at about the same period.

These beetles are somewhat closely related to the Japanese beetle, and in general correspond with it in larval and adult habits. Their economic importance is largely due to their capacity to injure and destroy lawns and grasslands. This is particularly true of the Asiatic beetle, and also applies to the Asiatic garden beetle. The latter, however, is in addition an active leaf feeder and attacks a large range of crop and ornamental plants. The Asiatic beetle has demonstrated a greater capacity to destroy lawns than the Japanese beetle, and possibly a greater capacity than any of our native species. According to the State entomologist of Connecticut, it has occasioned losses or costs of replacement during a short period of over $100,000 in only a small section of New Haven. The economic importance of these pests, therefore, must be measured largely by their menace to lawns and to all areas like parks and playgrounds, where grass is kept closely cropped. Therefore, taking a country-wide view, they are quite possibly becoming one of the most important and expensive of foreign insect introductions.

These beetles, particularly the Asiatic beetle, spread by their own powers slowly, but unfortunately, both of these beetles have already reached

important nursery districts, with the attendant risk of artificial carriage and opportunity for wide movement of the grubs in soil about plants or in other movement of soil, manure, etc. Balled plants from infested nurseries have been found to contain large numbers of the grubs in the stage in which the insect passes the fall, winter, and spring. The necessity, therefore, for the enforcement, with respect to nursery stock or other carrying products, of safeguards from these beetles would seem to be obvious.

At present the Asiatic beetles cover a considerable area in northern New Jersey and southeastern New York. There are also outlying infestations respectively at Albany, N. Y.—a determination of this year—at New Haven, Conn., Harrisburg, Pa., and in the District of Columbia. The main area of known distribution is within the Japanese-beetle area, and at the specific request of the States of New Jersey, Pennsylvania, and New York, the quarantine lines have been made conterminous with the area now under regulation in these States on account of the Japanese beetle, irrespective of actual areas infested by the Asiatic beetles. This is not true, however, in Connecticut where a special quarantine to prevent spread applying to the Asiatic beetle is being enforced by the State. Such adjustment is necessarily a matter of State rather than Federal determination. Unfortunately, the action by the other States named will probably have the effect of accelerating the spread of this pest into the portions of these States not already reached.

In the areas determined as actually infested, scouting of nurseries for the presence of these insects has resulted in the finding of 108 infested establishments. For the purpose of the quarantine, such nurseries have been classified after the same plan as that adopted for several years with respect to the Japanese beetle, except that of the present three classes provided for the Japanese beetle, Class II has been omitted. The two classes retained are, however, identical with the same classes for the Japanese beetle. These are as follows: Class I—those establishments located in districts included in the regulated area but in which neither grubs in the soil nor beetles have been found; and Class III—those establishments in which either grubs in the soil or beetles occur or which are located in districts known to be generally infested. (Class II in the Japanese-beetle quarantine covers nurseries located in districts recently or scantily infested by the beetle but in which nursery no beetles have been found and in which it has not been possible to determine any soil invasion.) The provisions of the Asiatic-beetle quarantine correspond to the similar provisions of the quarantine on account of the Japanese beetle and are being enforced by the Japanese-beetle organization.

THE PINK BOLLWORM

WESTERN AREA OF INFESTATION

The interest in the pink bollworm still centers in the western area of infestation, in which no thoroughgoing effort at eradication has ever been made, because of the proximity to Mexico and the consequent continued risk of reinfestation, and because of certain economic conditions in areas remote from the border, which have made the States concerned unwilling to authorize an intensive eradication effort such as was successfully concluded in the case of large areas of early infestation in eastern Texas and in Louisiana.

The subject of special interest is the infestation which was determined in connection with the 1927 crop in seven counties in the extension of cotton in western Texas north of the Pecos Valley. It will be recalled that this infestation was discovered during the first three months of 1928 and involved scattered points in the seven counties, and affected some 400,000 acres of cotton land. The special significance of this outbreak was that it was in direct connection with cotton-growing areas eastward. To handle this infestation, a special emergency increase to the pink-bollworm fund of $400,000 was obtained from Congress, and intensive clean-up operations were immediately instituted throughout the area. These measures included seed sterilization at all points of concentration in the area and an intensive clean-up of all gin premises, oil mill, etc., extending to all points outside of the area to which any seed had been carried. A plan of eradication was agreed upon between the State and the Federal Government involving the declaration of a non-cotton zone throughout this area of seven counties and in certain additional areas in Texas, including Brewster County in the lower bend of the Rio Grande, and by joint resolution and later by appropriation, $5,000,000 was made available by Congress for such purpose. Certain

verbal changes, however, which were made in the appropriation item at the last moment made this money unavailable for use in these seven counties, and the noncotton zone was established and maintained in Brewster County only.

In view of the failure of this opportunity, which, from past experience, might well have completed the eradication of the pest, it is pleasing to note that in connection with the crop of the following year, 1928, only a single infestation was found, namely, of two bolls in a field near Odessa. This favorable result must be accredited both to the intensive clean-up of the area in question made possible under the special emergency increase of $400,000 referred to and to conditions during the winter of 1927–28, which were unfavorable to the survival of the hibernating larvæ. In fact, all of the larvæ found in the field were dead, but it is well understood that larvæ in seed in gins or in other protected places would not necessarily have been injured by these weather conditions. It is, therefore, probable that the clean-up of all such seed and its sterilization has contributed a very important part in almost eradicating the insect.

The situation as to infestation for the crop of the current year is not yet known; it is not, however, improbable that infestations will later be discovered at different points in the area. On the other hand, eradication having reached such a state of completeness as it did with the crop of the preceding year, it may be found that the insect has been completely eliminated in this area.

The enforcement of a noncotton zone in Brewster County eliminated the insect for the year 1928. This county was replanted in 1929, and it will be interesting to note how much reinfestation will result. The main idea in extending the noncotton zone to Brewster County was to eliminate the possibility of spread by flight from that region to west Texas and New Mexico. The growing of cotton on the Mexican side of the river, however, will mean the immediate reinfestation of plantings on the Texas side, and to obtain complete protection, therefore, it will be necessary to maintain a continuing embargo against cotton production.

As indicated in previous reports, it is not practicable to undertake any thorough-going eradication measures in the Rio Grande Valley from the Big Bend to El Paso until Mexico can cooperate so that a clean-up of the cotton on both sides of the boundary can be carried out at the same time.

THE FROST INFLUENCE IN THE WESTERN AREAS

The records so far indicate that the western areas of cotton production in Texas are approaching the natural limits of spread and damage by the pink bollworm. Other than in the Big Bend district of Texas, there has been practically no commercial loss from this insect in these areas, and the fluctuation in abundance of the pest has been very considerable and in several instances nearly to the zero point—as for example, in the winter of 1927–28. Throughout this area there was a notable reduction in infestation in the crop of 1928, and in fact in a good many places apparently a complete disappearance of the insect. For example, no specimens of the pink bollworm were found in the previously determined areas of infestation in Arizona or New Mexico. It is true that these areas have also been subjected to intensive controls such as are enforced in connection with seed, gin trash, and lint throughout all infested areas, but the cold weather during the winter of 1927–28 must undoubtedly be accredited with a good deal of the reduction. Again, in 1928 in the infested field at Odessa, only two infested bolls were found. Ten insects were taken in a single boll, and of these seven were dead.

Similarly, the infestation throughout the Rio Grande Valley from Presidio to El Paso in 1928 was exceedingly light. Perhaps the heaviest infestation developed in Presidio County, increasing from June to the end of the season as follows: 0.08 per cent in June, 0.01 per cent in July, and 0.17 per cent in August. However, in September, with mature bolls present in all fields, there was a rapid increase averaging 0.33 per cent September 1–7, 4.18 per cent September 8–14, 7.18 per cent September 15–21, and 9.4 per cent September 22–30. In October the increase became even more rapid and was as follows: October 1–7, 19.36 per cent; October 8–14, 30.73 per cent; October 15–21, 43.55 per cent; and October 22–31, 57.32 per cent. The increase continued at a slower rate in November until frost. This data is given as indicating the rate of increase under favorable weather and food conditions.

In the Pecos and El Paso Valleys the decrease in infestation noted in

other western areas was also clearly evident.

In connection with this discussion, the extent to which the infestation has varied from year to year in the El Paso Valley, where full controls of seed and crop are in effect, is shown by a series of annual surveys which have been taken on the Ivey-Dale ranch, one of the most heavily infested ranches in the El Paso Valley and one which has been regularly planted to cotton. It should be noted that this valley has an altitude of 3,500 feet, and cotton is not infrequently subjected to early frost damage. Such early frosts, catching the larvae in various stages of immaturity, seem to be the important element in reducing numbers. In other words, the mature hibernating larva, as will be shown by experiments reported later, is capable of withstanding successfully very low temperatures. For each of the past eight years 54 man-days' inspection has been carried out on this ranch. The results are shown in Table 5.

TABLE 5.—*Annual fluctuations of pink bollworm infestation in El Paso Valley*

Crop year	Month of scouting	Specimens collected			Crop year	Month of scouting	Specimens collected		
		Alive	Dead	Total			Alive	Dead	Total
1928	February	0	0	0	1923	January	0	0	0
1927	January	1	11	12	1922	December and January	11	63	74
1926	January and February	0	2	2	1921	December	3	155	158
1925	December and January	0	252	252	1920	December	0	5	5
1924	January and February	0	3	3					

QUARANTINE LINE SLIGHTLY MODIFIED IN TEXAS

The only change in the boundary lines of the regulated area during the year was the release of a small district in the northern part of Dawson County, Tex. This portion of the county lies considerably north of the infested region as determined by inspection of the 1927 crop. As the northern boundary of the county was used as a quarantine line, the town of O'Donnell, with its seven gins, was divided. This made the segregation of cotton and its products from the regulated area at this point difficult and uncertain. When it was determined by an inspection of the 1928 crop that there had apparently been no outward spread of the pest, it was believed there would be no increase in risk from releasing this portion of the county, and moving the quarantine line to the south side of the O'Donnell ginning area. This action was taken on May 16, 1929.

FIELD INSPECTION

Field-inspection work is a very necessary corollary of regulatory activities of this kind. In the first place, infestation must be discovered and delimited before adequate control or eradication measures can be applied intelligently. In the second place, after such measures have been applied, it is necessary to determine the results. In this connection, attention may again be drawn to the continuing risk of reinfestation from Mexico. This risk so far as the movement of products from Mexico into the United States is concerned has apparently been successfully met by quarantine enforcement along the Mexican border, but an important element of risk which it has not been possible fully to safeguard against is the movement, across the border, in violation of immigration regulations, of thousands of Mexican laborers with their household effects, involving the carriage of more or less bedding and other articles stuffed with seed cotton. Very frequently such material when intercepted is found to contain living pink bollworms. A general survey of regions more or less affected by this movement is a necessity if new outbreaks of the pink bollworm are to be discovered in time to be effectively controlled and cleaned up.

A considerable force is required to cover the large areas now under regulation and also the various points under suspicion. During the year there was a total of 8,539 man-days' scouting done. Table 6 shows the distribution of this work, together with the results for the crop year 1928 and the four preceding years. Much less time has been devoted to the old eradication

areas in east Texas and Louisiana than in previous years. The intensive scouting carried on in such areas for several years following the finding of the last infestation eight years ago is deemed sufficient to warrant the conclusion that the pest has been eradicated in that region. In the lower Rio Grande Valley of Texas and adjacent Mexico, a total of 1,030 man-days' scouting was done, with negative results. A total of 2,809 man-days' inspection has been made outside any area heretofore known to have been infested, mostly in Texas. This includes 1,557 man-days of bollie inspection. Most of the points covered were under some slight suspicion for one cause or another. The results were negative.

TABLE 6.—*Summary of pink bollworm scouting showing number of man-days' scouting and number of infested fields for each of the districts scouted, crop years 1924–1928*

Area and district	1924		1925		1926		1927		1928	
	Man-days	Infested fields	Man-days	Infested fields	Man-days	Infested fields	Man-days	Infested fields	Man-days	Infested fields
Eradication areas:										
Hearne, Tex	0	0	0	0	0	0	0	0	0	0
Trinity Bay, Tex	1,046	0	787	0	828	0	1,025	0	97	0
Ennis, Tex	835	0	606	0	566	0	842	0	11	0
Marilee, Tex	612	0	237	0	283	0	418	0	20	0
Cameron, La	655	0	649	0	661	0	533	0	0	0
Shreveport, La	826	0	606	0	568	0	781	0	0	0
Infested areas:										
Pecos Valley, N. Mex.[1]	741	0	626	16	97	0	126	2	0	0
Pecos Valley, Tex	650	15	183	22	32	8	1	6	74	2
Mesilla Valley, N. Mex	158	0	155	0	47	2	303	6	76	0
Mesilla Valley, Tex	140	0	17	1	1	2	0	0	6	0
El Paso Valley, Tex	397	1	131	14	114	4	55	2	54	0
Big Bend, Tex	167	62	[2]	96	[2]	[3]	[2]	[3]	[2]	[3]
Big Bend, Mexico	[4]	2	0	0	[2]	[3]	[2]	[3]	[2]	[3]
Juarez Valley, Mexico	0	0	2	3	27	0	0	0	18	0
San Carlos, Monclova, Mexico	40	0	37	0	36	2	0	0	14	0
Deming, N. Mex	0	0	15	0	34	3	2	1	103	0
Duncan Valley, Ariz. and N. Mex	0	0	0	0	71	1	9	3	156	0
Gila (Safford) Valley, Ariz.	0	0	28	0	262	4	7	3	175	0
Cochise County, Ariz	0	0	11	0	160	10	20	4	21	0
Santa Cruz Valley, Ariz.[5]	333	0	197	0	339	0	454	1	85	0
Western extension, Tex.[6]	0	0	0	0	0	0	850	24	1,790	1
Suspicious areas:										
Uninfested western extension, Tex	16	0	746	0	967	0	1,684	0	2,000	0
Lower Rio Grande, Tex	354	0	886	0	671	0	592	0	974	0
Lower Rio Grande, Mexico	34	0	16	0	15	0	8	0	56	0
Other areas [7]	444	0	436	0	1,198	0	926	0	2,809	0
Total	7,448	80	6,371	152	6,977	36	8,636	52	8,539	3

[1] Infestation in this valley was confined in the past to Carlsbad and vicinity and is referred to in certain previous reports as "Carlsbad" infestation.
[2] Research examinations.
[3] Heavy infestation; exact number of fields not recorded.
[4] Figures not available.
[5] Includes plantings extending from Red Rock southward to Nogales.
[6] Inspections for 1924, 1925, and 1926 included in uninfested western extension.
[7] Covers scouting done around centers in the Cotton Belt to which seed from infested areas had been distributed in the earlier years of the campaign of eradication. These areas were thoroughly investigated for a number of years afterwards without finding any infestation, but it seemed advisable to give them an intensive resurvey before releasing them from further consideration.

CONTROL AND ERADICATION METHODS

The principal control or eradication measures which are enforced in the infested areas of west Texas and New Mexico and Arizona include (1) the destruction or safe disposal of gin trash, (2) the sterilization of seed at gins, (3) supervision of oil mills handling seed produced in infested areas, (4) fumigation and compression of lint, and (5) road quarantine stations for the purpose of intercepting restricted products being carried unwittingly or otherwise out of the area.

Destruction of gin trash.—All gins are equipped with cleaning machinery which removes from seed cotton con-

siderable foreign matter. It has been discovered that in an infested area a considerable number of pink bollworms are discharged in this gin trash. During the season as many as 500 larvæ have been found in the trash from a single bale in the Big Bend region of Texas. Examination of gin trash is, therefore, an important adjunct to field inspection. As illustrating the utility of gin-trash inspection, field inspection during the season of 1928 of 54 man-days on the Ivey-Dale ranch in the El Paso Valley did not reveal the presence of the insect. On the other hand, gin-trash examination in several parts of the valley showed the presence of the insect. Examination of gin trash was also the means of determining the presence of the insect in 1928 in the Pecos Valley of Texas.

In the western extension of cotton growing in Texas, and to some extent in other areas, it is customary to gather considerable cotton by processes locally called "snapping" and "sledding." By snapping is meant the gathering of bolls with the cotton, when the bolls, on account of early frost, have not opened sufficiently to enable the pickers to remove the seed cotton easily. By sledding is meant the dragging of a sled over the row, gathering as it moves, the cotton bolls together with a large amount of trash. In either case there is a great accumulation of waste at the gin. In some extreme cases there may be as much as 1,500 pounds of such material to a single bale of ginned cotton. Even in ordinary ginning, the daily accumulation of trash is large. It is important, therefore, as a control measure, that gin trash be cleaned up daily, and one of the duties of gin inspectors is to see that such trash is promptly burned, sterilized, or ground each day as it accumulates. Following a suggestion by one of our inspectors that some types of gin waste, if ground, might be useful as stock feed, such grinding and utilization has been tried out with some success, and there is good reason to believe that the better grades of such trash may be made into a useful by-product.

Seed sterilization.—The pink bollworm normally hibernates within cottonseed, and the proper treatment of seed constitutes one of the best means of control and should be credited with a large part of the success of our efforts in the infested western areas. The method consists in heating the seed to a temperature of 145° F., and all gins in regulated areas (137, including 9 in Mexico) are required to have seed-heating machinery equipped with a thermograph, so that a continuous record will be made. During the season 236,000,000 pounds of cottonseed were thus treated. This work is supervised, and each gin is visited at least once a day by an inspector, and all the machinery is checked to see that it is functioning properly. The thermograph charts are taken up daily and graded on the basis of the percentage of time they show a temperature above the minimum requirement. This means that the time required for changing bales or the time lost in temporary breakdowns is charged against the efficiency rating of the gin. Even on this basis the rating for this season had a high average, 94 per cent. The highest theretofore obtained was 91 per cent for the season of 1927. Taking into account the time lost in changing bales, occasional stoppage on account of breakdowns, and the fact that a slightly lower temperature than the minimum requirement will kill a high percentage of pink bollworms in cottonseed, it is safe to assume that the percentage of pink bollworms killed is higher than the average efficiency rating above indicated.

Supervision of cottonseed oil mills.—Notwithstanding the disinfection required for all seed as it leaves the gin as a continuous process, there is nevertheless a certain percentage of risk that is not eliminated by such treatment. Such seed is, therefore, prohibited movement out of the regulated area except where the circumstances are such as to necessitate its being taken to oil mills outside of the area. The lack of available oil mills in the area made it necessary during 1928 to license six mills outside of the area. These are located at Colorado, Sweetwater, Abilene, Lubbock, Slaton, and Amarillo, Tex., and so far as their operations relate to cotton from infested areas, they are under supervision of Federal inspectors both as to milling of the seed and subsequent clean-up. Seed was carried to these mills in sealed cars, unloaded, segregated, and crushed during the winter or early spring, before the cotton from the fields reached a stage of susceptibility to infestation, the crushing being completed prior to May 1, 1929. Cars hauling seed to mills were always cleaned thoroughly before being released. Seed was required to be ground to a degree to destroy all pink bollworms. To prevent contamination of finished products, the seed, linters, and grabbots were segregated until

treated in accordance with the regulations. Approximately 100,000 tons of seed were thus crushed under supervision during the season.

Lint fumigation.—In the regulated area there are nine vacuum fumigation plants operated under supervision. Table 7 shows the number of bales of lint and linters fumigated and compressed during the year.

TABLE 7.—*Bales lint and linters fumigated, 1928 crop*

Location of plant	Lint	Linters	Total
Big Spring, Tex.	63,158	4,191	67,349
Lamesa, Tex.	31,753	343	32,096
Marfa, Tex.	4,972	373	5,345
Fabens, Tex. (two plants)	61,565	3,317	64,882
El Paso, Tex.	11,448	4,092	15,540
Roswell, N. Mex.	32,535	2,235	34,770
Las Cruces, N. Mex.	45,476	1,332	46,808
Tucson, Ariz.	14,715	2,477	17,192
Total [1]	265,622	18,360	283,982

[1] 2,016 bales of Mexican lint and 18 bales of Mexican linters included in above figures.

Road stations.—At strategic points on the highways leading out of the regulated areas, traffic-inspection stations are maintained for the purpose of intercepting cotton products likely to carry infestation. During the year such stations were maintained at Gail, Coahoma, Sterling City, Girvin, Fort Stockton, Alpine, Fort Davis, and Valentine, Tex.; Lovington, Lordsburg, Silver City, and two near Roswell, N. Mex.; and one near Tucson, Ariz. In addition, the State of Arizona maintained stations at Rice and Springerville. At Roswell, N. Mex., it is necessary to maintain two stations in order to cover the two main highways leading eastward from the Pecos Valley. The station at Lordsburg is for the double purpose of intercepting eastbound products likely to carry the Thurberia weevil and westbound products likely to carry the pink bollworm. The stations at Valentine, Fort Davis, and Alpine, Tex. are for the purpose of preventing exit of material from the very heavily infested Big Bend area.

During the year 303,226 vehicles were stopped at road stations and inspected. Of these, 13,198 proved to be transporting 157,731 restricted articles from quarantined and regulated areas. It was necessary to confiscate and destroy much of this material, including 3,055 lots of seed cotton and cottonseed, 456 cotton-picking sacks, 1,312 quilts, pillows, and mattresses, and 686 lots of other materials—a total of 5,509 lots. Articles which it was possible to treat, disinfect, or clean at the inspection stations and permit to proceed included 3,461 cotton-picking sacks, 23 quilts, pillows, and mattresses, and 85 lots of other materials—a total of 3,569. Articles inspected and passed without treatment or found to be moving locally in compliance with Federal and State quarantine regulations included 145 lots of seed cotton and cottonseed, 11,896 cotton-picking sacks, 135,188 quilts, pillows, and mattresses, and 1,424 lots of other materials—a total of 148,653 lots.

EFFECT OF LOW TEMPERATURES ON PINK BOLLWORM LARVÆ

During April and May, 1929, some experiments were carried out cooperatively by the Plant Quarantine and Control Administration and the Bureau of Entomology to determine the effect of low temperatures on pink-bollworm larvæ. The purpose was to find out, if possible, what dependence might be placed upon the cold winters as an aid in the control of the pest.

The tests were performed by placing the larvæ in test tubes which were lowered in brine for the time and at the temperatures shown in Tables 8 and 9. The temperatures in the test tubes were found to be about 1 degree higher than those of the brine. Table 8 shows the results of exposing naked larvæ, and Table 9 shows the results of exposing larvæ within double seed, which is a decidedly more natural condition.

These tests indicate that naked larvæ are not injured at temperatures of 15° F. or above; that there is some mortality at 10° with four hours exposure or more, and that there is almost complete mortality at 5° or lower.

In the case of larvæ with the protection afforded by being within double seeds the results are somewhat more erratic; but there is apparently some mortality at 10° F. for four hours. It is interesting to note that a temperature of 0° for one hour does not give 100 per cent mortality.

TABLE 8.—*Summary of percentage of mortality of naked Pectinophora larvæ after brine temperature exposures of 32°, 25°, 20°, 15°, 10°, 5°, and 0° F. at from 1 to 8 hour periods (series A)*

Exposure (hours)	Percentage of mortality after brine temperature exposures of—						
	32° F.	25° F.	20° F.	15° F.	10° F.	5° F.	0° F.
1	33	[1] 22	20	30	20	100	100
2	20	20	60	30	[1] 30	100	100
3	60	0	[1] 20	[1] 30	[1] 20	100	100
4	10	40	10	[1] 10	[1] 70	100	100
5	55	10	40	10	89	100	100
6	30	[1] 20	30	[1] 10	60	100	100
7	[1] 33	[1] 20	40	[1] 20	70	100	100
8	30	40	30	[1] 20	60	100	100
Check	20	[1] 60	10	[1] 0	50	[1] 20	10

[1] Pupation.

TABLE 9.—*Summary of percentage of mortality of Pectinophora larvæ in infested double seed after brine temperature exposures of 15°, 10°, 5°, and 0° F. at from 1 to 8 hour periods (series B)*

Exposure (hours)	Percentage of mortality after brine temperature exposure of—			
	15° F.	10° F.	5° F.	0° F.
1	24	3.4	51.5	92.9
2	11	8.1	65.2	100
3	14.8	20.5	95.1	100
4	0	[1] 53.6	100	100
5	[2] 6.7	[2] 65.3	100	100
6	14.3	[1] 68	[1] 97.1	100
7	18.8	[1] 76.9	100	100
8	12.5	[1] 73.5	100	100
Check	6.7	4.5	37.5	25

[1] Imperfect pupation.
[2] 1 larva reacts to stimulus only; considered recovered.

COOPERATION WITH MEXICO

There are some 15,000 acres of cotton grown in the Rio Grande Valley of Mexico adjacent to the Texas fields in the El Paso Valley and in the Big Bend. A good deal of this cotton belongs to American owners, and much, if not all, of it would normally be handled and find its market on the United States side. It follows that insistent demands have been made for permission to handle and utilize the local Mexican crop in this manner. Advantage of this demand has been taken to enforce, as a condition of such marketing in the United States, the adoption of all precautions which are being enforced on the United States side, both as to the sterilization of seed and clean-up of gins, and later, as a condition of entry, the requirement of disinfection and compression of cotton. For the control of the pink bollworm in these districts the Mexican Government has promulgated regulations which are essentially similar to the regulations supplemental to Federal quarantine 52. The officials and citizens of Mexico have manifested an excellent spirit of cooperation in this regard.

THE THURBERIA WEEVIL

As has been noted in other reports, the Thurberia weevil is identical with the ordinary Mexican cotton boll weevil except that it has been separated from the latter for ages in certain interior valleys of Arizona, where it has maintained itself on a wild plant somewhat remotely related to cotton. With the development of cotton culture in small irrigation districts in these valleys it has found in cotton a plant much more favorable to its increase than the native Thurberia plant. As previously pointed out, also, its high importance to commercial cotton production in the more arid regions of the United States is the fact that in these ages it has adapted itself to such conditions in Arizona, and therefore these conditions, which inhibit the ordinary Mexican boll weevil, are, on the contrary, favorable to this native weevil cousin. The latter may, therefore, easily become a menace throughout the areas of western Texas, Arizona, and New Mexico which so far have been immune to the Mexican boll weevil.

The department is endeavoring by quarantine measures to prevent the spread of the Thurberia weevil from the Arizona valleys and by clean-up and control measures to keep it from occasioning important damage in those sections so far as is possible. Its erad-

ication would seem to be out of the question except by expenditures of enormous sums to eliminate the Thurberia plant in adjacent and surrounding mountain canyons.

The principal area invaded by the Thurberia weevil lies south of Tucson in the valley of the Santa Cruz. During the 1928 crop season there was a very considerable increase of the Thurberia weevil in this area. The scouting done by inspectors of the Bureau of Entomology shows that at Continental 9.3 man-days' scouting disclosed, in 1928, 423 infested bolls (306 weevils), an average of 45.5 infested bolls and 32.9 weevils per man-day, as compared to 13 infested bolls and 9.8 weevils per man-day in 1927. At Sahuarita 6.4 man-days were devoted to inspecting, and 92 infested bolls and 78 weevils were found, or an average of 14.4 infested bolls and 12.2 weevils per man-day, as compared to 2.5 infested bolls and 1.2 weevils per man-day in 1927. At Tucson, or in the Midvale area, 12.9 man-days were devoted to scouting, and 93 infested bolls and 81 weevil specimens were found, or an average of 7.2 infested bolls and 6.3 weevils per man-day, as compared to 2.3 infested bolls and 1.8 weevils per man-day of the previous year. These comparisons show a distinct weevil increase in the Santa Cruz Valley south of Tucson during the past season—heavier in the southern end of the valley. The scouting of the other Thurberia-weevil areas north of Tucson and in the San Simon and Wilcox sections indicated no weevil increase.

By cooperative arrangement with the Buerau of Entomology, the scouting to determine spread of this weevil is assumed by that bureau in connection with its research work on this insect, the quarantine remaining in full charge of the Plant Quarantine and Control Administration.

The measures of control for Thurberia weevil are the same as those enforced for the control and eradication or prevention of spread of the pink bollworm, namely, disinfection of cottonseed as a continuous process of ginning, compression and vacuum fumigation of lint, cleaning up of points of concentration, and road-station inspection. The totals given elsewhere of number of bales fumigated, gins in operation, tons of seed sterilized, and road-station interceptions in the report on pink-bollworm suppression include both pink-bollworm and Thurberia-weevil activities.

MEXICAN FRUIT WORM

REDISCOVERY IN SOUTHERN TEXAS

After the elapse of almost two years, from June, 1927, to April, 1929, during which no Mexican fruit-worm infestations were found in the Rio Grande Valley of Texas, this insect was rediscovered last spring in stored fruit after the commercial citrus crop had been harvested and for the most part shipped. The infestations were found on the premises of 10 growers and 2 packing houses in Hidalgo County. They were chiefly limited to the small quantities of stored fruit on these premises, except that in two instances larvæ were found in grapefruit on the trees where such fruit had previously been overlooked in the tree-to-tree clean-up and inspection. The first four properties discovered to be infested were grouped around Mercedes in the southeast corner of Hidalgo County, and additional properties were later found in the vicinity of Mission, which is located 20 miles farther west. Practically all fruit remaining in storage in the regulated area was given a careful inspection, but no infestation was found in fruit in other parts of the district.

It is believed that the new infestation has now been completely eliminated and that there will not be a possibility of the pest being carried over into the 1929–30 crop.

Prior to this discovery and at the urgent request of the growers, the time for harvesting the crop of 1928–29 had been extended for the season of 1929 from February 28 to March 30. This action was due to the lateness of the crop in maturing, the unusually weak demand for citrus fruits throughout most of the season, the seeming absence of an infestation during this and the preceding crop, and the practically complete elimination of alternate-host-fruit trees within the area, assuring a host-free period of approximately the same length as in the preceding year.

Extending the time thus for the fruit to remain on the trees is believed now to have been a mistake. Infested fruit from central Mexico was reaching the Mexican towns along the border, and the presence of susceptible fruits on the trees in Texas throughout the month of March apparently gave opportunity for the insect to become reestablished after the pest had been eradicated two years before.

It is clearly inadvisable in the future to consider extension of the harvesting

season beyond the end of February. Growers themselves realize that the extension requested was apparently responsible for the infestations, and it is not probable that similar application will be made again, at least for years to come.

Upon determination of the infestations, all permits to pack and ship citrus fruits were canceled. Shippers were notified that all fruit held in storage within the quarantined area could be moved only to points north of the Cotton Belt.

ELIMINATION OF SECONDARY HOST TREES

A very strong effort, in 1928, was directed toward the completion of the elimination of the summer-host fruit trees in order that the citizens of the region might not be subject to the inconvenience of picking the green fruit each season. Surveys showed the presence of 37,293 such secondary host trees, mainly peaches and plums, most of them scattered in small numbers in farmyards and in private gardens located in cities and villages.

After the commercial grapefruit and orange crops had been picked in February, 1928, department inspectors devoted much time and attention to presenting to the owners the importance of the destruction of such trees. The first to respond were those who also possess citrus groves, and who were therefore vitally concerned with the success of this project. Community interest and public sentiment supported the campaign, and those who were not commercially affected rapidly followed the lead of the others. No legal pressure was employed, as official regulations require only the picking of the green fruit, but most owners realized how objectionable such continuing picking and destruction would become.

Since the inauguration of the quarantine in 1927, 4,513 premises have been cleaned of 37,216 secondary-host trees, and in addition many trees were destroyed in the summer of 1927 of which we have no record. At the present time there are 14 known premises with 77 trees left in the area. As only a small proportion of the owners of the trees destroyed had anything to gain personally, the entire undertaking has been an inspiring example of cooperation with much individual sacrifice of cherished trees and shrubs.

ORCHARDS CLEANED UP SATISFACTORILY

An important feature of the eradication program consists in the collection at frequent intervals and the prompt destruction by burying or other means of fallen fruit in the orange and grapefruit groves. This is considered so important that the fruit from orchards in which this is not done is refused certification.

Each bearing grove was inspected once during each 30-day period until the fruit was harvested. Many of the town lots required only one inspection during the shipping season. In cases where there were excessive amounts of fruit on the ground or growth of weeds in the orchard the "certificate of inspection" was withheld until the groves were put in proper shape. A total of 14,334 inspections were made of groves during the shipping season from September 15 to March 29. Of this number 540 reinspections were necessary because of dropped fruit or weed growth. At the close of the shipping season, March 29, tree-to-tree inspections were made of all bearing trees in the quarantined area. In addition, inspections were made of certain selected groves in Mexico for the presence of the infestation.

Enforcement of the regulations has caused the groves to be kept cleaner and in a much more sanitary condition than before the quarantine became effective, and this has been favorably commented upon by many individuals who visit the valley.

CITRUS CENSUS

The numbers of citrus trees growing in the area, as tabulated in July and August by the district inspectors, totaled 3,419,157. Seventy per cent of these trees were grapefruit, of which 85 per cent were late-maturing varieties. Twenty-eight per cent were oranges, of which 63 per cent were early-maturing varieties. Only 21 per cent of the trees listed had come into bearing. Sixty-two per cent of the trees listed were in Hidalgo County, 36 per cent in Cameron County, and 2 per cent in Willacy County.

PACKING PLANTS AND CANNERIES

Packing houses were inspected daily while in operation. Fruit, in the process of being packed, was inspected for signs of insect injury. An investigation was made of the origin of the fruit on hand to see that the packers were not picking fruit from unauthorized groves. An inspection was made of the premises to see that they were kept in a clean and sanitary condition

and that all fruit débris and culls were properly disposed of.

Canneries were operated at Corpus Christi, McAllen, Olmito, and Los Fresnos for the preservation of cull fruit. These were inspected regularly when canning was in progress to see that proper disposition was made of fruit waste and rejects.

Permits to pack and ship approved citrus fruits were issued to 269 firms and individuals, and a total of 907,249 tags were supplied to the permittees.

During the season, 1,745 carloads of fruit were moved from the quarantined area by rail. The minimum load was three hundred and forty-eight 80-pound boxes, as compared with a minimum of 310 for the previous season. Eighty-one thousand one hundred and seventy 80-pound boxes, or approximately 233 carloads, were moved by express, 160,029 boxes and baskets, or approximately 445 carloads, were moved from the quarantined area by truck and auto. Very little was shipped by parcel post. Thus, approximately 2,423 carloads of fruit were moved from the quarantined area during the season 1928–29.

ROAD TRAFFIC

Practically all road traffic leaving the valley is over the Edinburg–Falfurrias Highway. A station was established at Encino, Brooks County, on this highway for the inspection of vehicles leaving the quarantined area which might be carrying contraband fruit. During the period from October 8 to April 12, 31,614 vehicles were inspected. Of this number the following carried fruit:

Trucks with permitted fruit	2,474
Passenger cars with permitted fruit	5,321
Trucks with contraband fruit	16
Cars with contraband fruit	3,528

In all cases owners of contraband fruit were given the privilege of returning it to the quarantined area. One thousand two hundred and nine bushels of such fruit were confiscated from travelers who did not care to avail themselves of this opportunity. This fruit was destroyed.

The station at Encino was closed April 12 but was reopened upon the finding of the infestation and the placing of the embargo on valley fruit. Owing to the inauguration of the Texas quarantine against Florida fruit, traffic moving in both directions has been inspected since April 23, 1929. The Mission–Rio Grande City–Laredo road was also guarded at various times throughout the season, but there was not enough traffic to justify a station. Two inspectors were placed on this road during May and June.

PUBLIC SUPPORT

On the whole the support given to the quarantine regulations by both growers and business interests of the valley has been all that could have been desired. Occasional violations by the growers have involved improper disposal of dropped fruit and by packers, the harvesting of fruit from groves before securing the required approval based on inspection.

Charges were filed in local courts against two individuals. In one case peaches had been allowed to reach a ripening condition. This case was settled, before it came to trial, by the owner's destroying the trees. In the other case an individual sold fruit from an infested grove. This case is still pending.

DATE-SCALE ERADICATION

SCALE-ERADICATION PROGRAM OUTLINED FOR THE FISCAL YEAR 1929

The reorganized scale-eradication program outlined in my last annual report has been pushed vigorously during the fiscal year just closed. Under this revised plan of operation two lines of work have been carried on simultaneously: (1) Reconnaissance surveys in the Imperial Valley of California and other date-growing areas of the Southwestern States, and (2) intensive date-scale eradication operations in the Coachella Valley of California and in the vicinity of Phoenix, Ariz.

The purpose of the reconnaissance surveys is to locate and map the points at which date palms are grown and to clean up any outbreaks discovered in the course of this work. These rapid surveys are to be followed later by intensive examinations of all palm plantings and by the eradication of all Parlatoria infestations discovered. In the intensive eradication areas, on the other hand, careful and repeated inspections are being made of all the palm plantings in the districts concerned in an effort to accomplish eradication at the earliest possible date.

The general or reconnaissance survey of the date-growing areas of the United States occupied the attention of a considerable force throughout

most of the fiscal year. By June, 1929, this phase of the program had been largely completed, and for the fiscal year 1930 it will be possible to devote a larger share of attention to intensive scale-extermination work.

The working out of the revised and enlarged program has already resulted in an improvement in the general situation. The number of infested palms found is decreasing from month to month, although the number of palms intensively examined becomes larger as the inspectors are being transferred from time to time from the general surveys to the work of scouting in the vicinity of infestations. An important factor in the improved conditions has been the adoption of the policy of destroying abandoned and uncared-for palm plantings—mostly seedlings of small value. Between January 1 and June 30, 1929, 16,987 palms were so destroyed, consisting mainly of slightly infested gardens without commercial value or of palms not actually found infested but located in danger zones.

The scale-eradication program is carried out in cooperation with the States of Arizona and California. The current Federal appropriation act authorizes the expenditure of Federal funds between February, 1929, and June 30, 1930, in the amount of $86,700, of which $70,000 is made conditional on a joint contribution for this purpose from the States of Arizona and California amounting to $35,000. Such appropriations have been made by the States concerned, and the total Federal and State funds available for the period indicated, therefore, amount to $121,700.

As additional amounts became available the personnel was increased from 14 in December to 32 in June, the places being filled as rapidly as suitable men could be obtained and trained.

The details of this work are given from time to time in the Service and Regulatory Announcements of the administration. A general statement of the conditions in the several date-growing areas follows.

COACHELLA VALLEY

During the year, 198,392 palm inspections were made in the Coachella Valley, and a total of 430 infested palms were found on 27 properties, 9 being new infestations. Two of the new infestations were dooryard plantings found in the town of Palm Springs, 3 were in large seedling gardens (practically all palms were destroyed), and 4 were in commercial plantings. Eight of the new infestations were light, and the possibility of spread from them was negligible. One seedling garden which was overlooked in the 1928 survey was quite heavily infested, and there is considerable danger of spread from it. Of the 430 palms found to be infested, 244 were destroyed, 106 were defoliated and torched, and 80 were given other treatment. In addition 16,657 palms in the infested area were destroyed. Five properties showing scale in the fiscal year 1928 showed no scale in the fiscal year 1929. All old infestations show a reduction in the number of infested palms in 1929 as compared with the number in the previous year.

IMPERIAL VALLEY

The first survey of the Imperial Valley was completed in December. Including some 4,461 palms found later, the total number now known in this valley amounts to 33,044. In all 42,208 palm inspections were made, and 1,115 palms on 60 poperties were found to be infested, 54 of the properties being new infestations. Most of the plantings found to be infested were small and of little value. Nine hundred and eighty-five infested palms were destroyed, 120 were defoliated and torched, and 9 were given other treatment. Thirty-eight palms not found to be infested but near infested palms were destroyed.

PHOENIX DISTRICT

The first survey of the Salt River Valley has been completed, 32,405 palms being located. In all 55,291 palm inspections were made. Forty-five infested palms were found on 12 properties. Eight of the infested palms were destroyed, and 37 were defoliated and torched.

YUMA DISTRICT

The survey of this district has not been completed. Over 15,000 palm inspections have been made in the previously infested area, and no scale has been found.

RIO GRANDE VALLEY

A hasty survey was made in the lower Rio Grande Valley between Laredo and Brownsville, Tex., and no infestation was noted on the 9,615 palms located and mapped.

QUARANTINE ON DOMESTIC NARCISSUS

The most important development of the year in narcissus-quarantine enforcement has been the authorization of the use of calcium cyanide as a fumigant for fly-infested bulbs.

Both the hot-water and the carbon-disulphide treatments heretofore employed have met with some objections on the part of producers, and the Bureau of Entomology has carried on investigations for several years to develop more satisfactory methods. By the summer of 1928, this work had reached a stage which seemed to justify the approval of fumigation for bulb flies with calcium cyanide, as an alternative to the employment of either hot water or carbon disulphide under vacuum. Accordingly, on July 12, such calcium-cyanide fumigation was authorized by the administration, and detailed requirements as to the nature and size of the fumigation chambers and the dosage and other conditions of fumigation were issued to the growers as circular PQCA–217. In the bulb-fly-infested regions, this method has since been adopted almost to the exclusion of other methods.

Under the provisions of the bulb-quarantine regulations certification authorizing interstate movement of narcissus bulbs without treatment is based on two inspections per year to determine freedom from pests; one carried out in the field during the blossoming period of the plants, and the other made while the bulbs are in storage after harvesting. These examinations are made by the inspection services of the various States cooperating with the Plant Quarantine and Control Administration.

In case infestation is found on the premises of a narcissus grower, the bulbs are required to be treated to eliminate the infestation. The treatment for eelworms consists of immersion in hot water maintained at a temperature of from 110° to 111.5° F. for two and one-half hours. During 1926 and 1927 the same treatment was required in case of bulb-fly infestation, with the option of substituting carbon-disulphide fumigation under vacuum. For the year 1928, the hot-water-treatment period was reduced to one hour in plantings in which bulb flies alone (that is, without eelworms) had been discovered, and later calcium-cyanid fumigation was authorized as indicated above.

The number of narcissus bulbs available in the United States has been increasing yearly. During the calendar year 1928, State inspectors reported that they examined plantings containing 224,782,287 bulbs, of which 132,126,940 were Paper White and other polyanthus types grown in the South, and 92,655,347 were the hardy daffodil types common in the Northern States. A total of 166,900,393 bulbs was reported as having been certified for interstate movement, of which 65 per cent were certified as uninfested and the remaining 35 per cent were treated. The figures for the different States have been published in the Service and Regulatory Announcements of the administration. (See S. R. A.–98.)

Bulb production is strongly localized. Over 98 per cent of the Paper White and other polyanthus types are grown in the States of Florida, California, South Carolina, Texas, and Georgia, which rank in importance in the order named. The State of Washington surpasses all other States in the number of bulbs of the daffodil type, reporting a total of 42,171,315. Other States reporting more than 1,000,000 daffodil bulbs each are as follows: New York, California, Oregon, Michigan, Texas, Virginia, New Jersey, North Carolina, Rhode Island, Illinois, and Maryland, ranking in importance in the order named.

The lesser bulb fly has been reported in all the States named except North Carolina, South Carolina, and the States bordering on the Gulf of Mexico. The greater narcissus fly has been found in California, New York, Oregon, Rhode Island, and Washington. Bulb-eelworm infestations during the year were reported from Kansas, Michigan, New York, North Carolina, Ohio, Rhode Island, Washington, and the District of Columbia. The eelworm infestations on the Pacific coast, which were causing considerable loss when the bulb quarantine was first issued in 1926, have been brought under control to a very satisfactory extent, and the eelworms have been almost eliminated from those areas in which narcissus are grown for bulb propagation.

Violations of the bulb quarantine during the year were confined largely to instances in which packages of narcissus were shipped without a grower's certificate or dealer's tag. Investigation showed that in most cases the bulbs concerned had been properly inspected and certified but that through negligence or otherwise the tags had not been attached. Most of the interceptions were made by inspectors engaged in enforcing the

white pine blister rust quarantine, and the details are presented in the report of that project.

WHITE-PINE BLISTER RUST QUARANTINE ENFORCEMENT

The largest 5-leafed pine-growing areas of economic importance in the United States which have not yet been reached by the white-pine blister rust are the sugar pine stands of the Sierra Nevada Mountains, extending from southern Oregon through much of eastern California, and the extensive white pine stands of the Appalachian range south of southern Pennsylvania. Of lesser importance are the limber pine stands of the eastern border of the Rocky Mountain region, and the ornamental pine plantings of the central Mississippi Valley. The department is endeavoring to delay the introduction of the blister rust into these regions by preventing the movement of infected pine and Ribes nursery stock.

The work of the Plant Quarantine and Control Administration with respect to white-pine blister rust control includes, (1) preventing the interstate movement of possibly infected pine trees and currant and gooseberry plants into 5-leafed pine-growing areas which the blister rust has not yet reached; (2) assisting States which have established blister-rust-control areas in preventing the reintroduction of Ribes into such areas, and (3) inspecting (in the generally infected States) pine-growing nurseries whose owners desire to raise 5-leafed pines under such sanitary conditions that they may be authorized to ship such pines to lightly infected States.

TRANSIT INSPECTION

As an important phase of the enforcement of the restrictions on the interstate movement of white pine, currant, and gooseberry, transit inspections are made during the fall and spring shipping seasons of express, parcel post, and freight at important distribution centers in various parts of the United States. The points manned during the fiscal year, the number of shipments inspected, and the number of shipments violating the various domestic quarantines which were intercepted are shown in Tables 10 and 11. The number of violations of the white-pine blister-rust quarantine constitute only about one-fourth of the total number of interceptions, violations of the Japanese beetle, European corn borer, and narcissus bulb quarantines, also being numerous.

TABLE 10.—*Shipments of nursery stock and other plants and plant products inspected in transit, July 1, 1928, to June 30, 1929*

Station	Period	Carrier			Total
		Parcel post	Express	Freight	
Chicago	Fall	24,971	2,252	18	27,241
	Spring	184,362	26,650	1,672	212,684
Kansas City	Fall	1,078	676		1,754
	Spring	49,615	8,265		57,880
Omaha and Council Bluffs	Fall	2,249	112		2,361
	Spring	7,831	2,717	439	10,987
St. Paul	Fall	1,159	436		1,595
	Spring	29,289	7,683	70	37,042
St. Louis [1]	Fall	90	23		113
New York	Spring	84,426	797		85,223
Denver	Spring	3,244	1,341	517	5,102
Ogden	Spring	701	831	28	1,560
Portland	Fall	3,515	1,006	120	4,641
	Spring	16,779	3,820	120	20,719
Spokane	Fall	1,435	218	50	1,703
	Spring	15,985	2,209	402	18,596
Seattle	Fall	6,150	1,837	1	7,988
	Spring	8,130	1,687	54	9,871
Total		441,009	62,560	3,491	507,060

[1] Few days only.

TABLE 11.—*Summary of shipments of nursery stock and other articles intercepted in violation of Federal plant quarantines at transit inspection points, July 1, 1928, to June 30, 1929*

Station	Q. 63		Q. 62[1]		Q. 38		Q. 43		Q. 45		Q. 48		Q. 53		Q. 66		Q. 48 and 66		Q. 52 and 61		Total	
	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
Chicago	29	43	70	36		5	47	24	3	10	2	13		5	1		9	21			161	157
Kansas City	3	7	56	2			1	2		2		1		1	1			1		1	61	17
Omaha	4	1	11																		15	1
Council Bluffs	3		14	1											1			1			18	2
New York	3	2	1	1					3	5	2			1	1		51	44			61	53
St Paul	9	16	17	8								1		1							26	26
St. Louis	1										1										2	
Spokane	1	4	6	3		4															7	11
Seattle		8	1	5										3							1	16
Portland	12	7	10	6		1															22	14
Denver		2																				2
Ogden	3	1																			4	1
Total	68	91	186	62	0	10	48	26	6	17	5	15	0	11	4	0	61	67	0	1	378	300
Grand total																						678

[1] In addition to the figures given here with respect to the narcissus-bulb quarantine (Q. 62), 12 violations were reported by State officials and others not engaged in transit inspection.

NOTE.—The figures given in this table represent the number of shipments intercepted in violation of the quarantine whose number appears at the top of the column, e. g. Q. 63 refers to the white-pine blister-rust quarantine; Q. 62, to the narcissus-bulb quarantine; Q. 43, to the European corn-borer quarantine, etc. Under each quarantine, the violations by commercial shippers are separated from those by noncommercial shippers, the former being indicated by C and the latter by NC. All the violations reported above were intercepted by blister-rust inspectors. In addition, 23 violations of the white-pine blister-rust quarantine and 19 violations of the narcissus-bulb quarantine were reported to the blister-rust office from outside sources.

In addition to the points shown, inspections were made for brief periods at Detroit, Indianapolis, Buffalo, Rochester, Philadelphia, and Washington.

In the conduct of this work the administration has received the hearty support of the Post Office Department and the railroad and express companies, the assistance at Chicago being especially gratifying. The express and mail employees at the larger stations set aside plant products for examination by the inspectors, and inspection tours are arranged in such a manner that no delay in dispatch is caused. Railroad employees have supplied full information in advance by telegraph and mail as to nursery-stock movement through freight terminals continuously for long periods whenever requested to do so. This assistance is a very material factor in the high percentage of shipments of plant products seen by the administration inspectors.

Increased care is being shown each season by the public and the transportation agencies concerned in determining before shipment that parcels of plant material comply in full with Federal quarantine regulations. When the first transit inspection work was done in 1920, 120 violations of Federal quarantines were intercepted with each 10,000 plant shipments seen by the inspectors. By 1924 this proportion had been reduced to 18 violations per 10,000 plant shipments, and by 1927 to 11, a proportion which has since been approximately maintained. The improvement for commercial nurserymen is even more marked, for in 1920 89 per cent of the interceptions consisted of packages sent by commercial concerns, while in 1929 only 55 per cent were sent by such companies. The percentage in 1929 would have been much less had it not been for the change in the narcissus quarantine marking requirements, which were insufficiently understood by the bulb producers during the fall. Such misunderstandings resulted in over 200 interceptions of bulb packages from commercial producers which had not been labeled or certified in accordance with the quarantine requirements, although investigation later proved that in most cases the bulbs concerned had originally been properly inspected.

Transit inspection activities constitute an important "second line of defense" in the enforcement of domestic quarantines and in preventing the spread of pests. As elsewhere noted,

this service is especially valuable also in connection with the enforcement of other domestic quarantines. Unauthorized or uncertified shipments of articles restricted as to interstate movement under these quarantines are frequently intercepted at outside distribution points. In view of the very considerable demonstrated value of such transit inspection, the Plant Quarantine and Control Administration is requesting, in connection with its estimates for the fiscal year 1931, authority to organize this service as a separate project to cover this field not only for the blister-rust quarantine but for all other domestic-quarantine subjects.

PROTECTION OF THE BLISTER-RUST CONTROL AREAS

The States of Connecticut, Idaho, Maine, Massachusetts, Michigan, New Hampshire, New York, and Rhode Island have established, under the authority of State laws, local blister-rust-control areas, in which the planting and possession of currant and gooseberry plants are prohibited in order to make the growing of healthy white pines in such areas possible. The State of New York has also set aside certain currant and gooseberry growing areas wherein the planting of 5-leafed pines is not permitted. Since both 5-leafed pines and Ribes must be present together in the same localities for blister rust to develop, this separation of host plants results in the permanent protection of the pines or Ribes concerned.

In order to prevent the importation into these areas of the prohibited trees and plants the Federal white-pine blister-rust quarantine requires that a control-area permit must be secured from the proper officer of the State concerned before currant or gooseberry plants or 5-leafed pines may be shipped in interstate commerce into any part of the States listed. The proper officer thus has the opportunity of refusing to issue such permits when the plants are intended for movement into the blister-rust-control areas.

The list of violations shown in Table 11 includes those instances in which nurserymen or others consigned prohibited plants to States having legally established blister-rust-control areas without having secured the control-area permit required. In all such instances, the shipments were turned back to the consignor, and where real negligence appeared to have been involved, legal proceedings have been instituted. No cases of deliberate intention to violate this restriction have been observed.

SANITATION REQUIREMENTS FOR PINE-PRODUCING NURSERIES IN HEAVILY INFECTED STATES

For several years the shipment of 5-leafed pines from New York and the New England States and the State of Washington was entirely prohibited on account of general infection existing in parts of those States. In the meantime, however, investigations carried on by the Bureau of Plant Industry have confirmed the effectiveness of the Ribes-free zone as a permanent protection to 5-leafed pine stands. Accordingly, in the last revision of the blister-rust regulations, which became effective August 15, 1928, provision was made for the interstate movement under permit of 5-leafed pines from the generally infected areas indicated into the more lightly infected States east of the Mississippi Valley quarantine line and also from Washington into Oregon and Idaho, when such pines have been raised from seed in a nursery free from currant and gooseberry plants and with a Ribes-free zone around the premises. The width of the Ribes-free zone is specified as 1 mile for European black-currant plants and 1,500 feet for other species of currants and gooseberries. This zone is required to have been maintained since the time of planting of the seed from which the pines have been grown. Inspection to determine freedom from such currant and gooseberry plants and the absence of blister rust from the nursery is also required.

Applications have been received from nine New York and New England nurseries for certification under these provisions. In five instances wild or cultivated currant and gooseberry plants were found within 1,500 feet of the nursery premises and it was necessary to withhold certification of the premises concerned. In most of these five instances the nurseries are taking steps to eliminate the Ribes, with the expectation that the premises will be able to qualify for this certification at some future time. In an additional pine-growing nursery, blister rust was found on the premises, and in still another instance, while no Ribes were found within the 1,500-foot zone, there was evidence of such Ribes having been present in the past since the pine seed had been planted. Certification was necessarily refused

in both the latter two cases. The two remaining nurseries from which applications have been received, one in Maine and one in Vermont, have qualified under the quarantine requirements. A permit was issued to one of these nurseries during the fiscal year and to the other shortly after its close.

THE PHONY DISEASE OF PEACH

As a result of investigations begun in 1921, the Bureau of Plant Industry last fall recommended the establishment of a quarantine against a type of infection known as the phony peach disease. A hearing on the subject was held on December 17, 1928, and a quarantine, restricting the movement of peach and nectarine trees, peach and nectarine roots, and other trees and shrubs grafted or budded on peach or nectarine roots, from the known infected area, was later issued, effective June 1, 1929.

The disease concerned is believed to have been present in Georgia for 40 or 50 years and to have been responsible for the dwarfing of certain trees, to which the name of "pony trees" was given, in the vicinity of Marshallville, Ga., during the eighties. The condition did not become extensive enough to cause alarm until 1915, but by that time enough dwarfed trees were observed in the Fort Valley area to cause one of the growers to bring the matter to the attention of the Bureau of Plant Industry. Experiments were started by the bureau in Fort Valley in 1921, but it was not until recently that the condition was definitely determined as being transmissible.

The infection now centers at Fort Valley (where over 99 per cent of the trees in some orchards have been attacked), but outlying points of infection have also been found throughout a large part of the State, covering 90 per cent of the fruit-production area of Georgia and extending west into Lee County, Ala. North of Macon, the disease is much less prevalent, from a trace to 10 per cent being present in certain districts.

The object of the hearing referred to above was to reach a decision as to the practicability of undertaking the eradication of this disease and to determine the need of quarantine restrictions to prevent its further spread as an aid in the eradication effort. It seemed evident that there must have been large opportunity for the disease to have been transmitted widely in the United States during the long period of its existence in Georgia in view of the known distribution of nursery stock from the general area now considered infected. On the other hand, no records have been obtained of the establishment of this disease elsewhere than in Georgia except in the adjacent point in Alabama.

The decision was reached that it was desirable and advisable to attempt eradication of this disease. The eradication measures, namely, the destruction of all infected plants or orchards, are being carried out by the Bureau of Plant Industry under a specific appropriation. The work of preventing spread is being carried out by the Plant Quarantine and Control Administration under the Federal quarantine to which reference has been made.

The principal danger of spread to distant points is believed to be with the movement of nursery stock, as neither scions, seeds, nor fruit are believed to be able to carry the disease to new locations.

The important restriction under the quarantine is that peach trees, peach roots, nectarine trees, nectarine roots, and kinds and varieties of trees or shrubs grafted or budded on peach or nectarine roots when originating within a regulated area, must not be moved interstate unless they "have been produced in a nursery within which, and within 1 mile of which, no infection of the phony peach disease has existed for at least two years prior to the proposed date of movement."

BLACK STEM RUST QUARANTINE

The Bureau of Plant Industry in connection with the States concerned is undertaking, under a special appropriation from Congress, to eradicate from a group of 13 North Central States the barberry and other plants involved in the transmission of the black-stem rust disease to wheat and other small grains. The quarantine on account of this disease, enforced by the Plant Quarantine and Control Administration, is to support and aid this effort by prohibiting the movement into these States of the common barberry and related plants which harbor one phase of the disease.

The following figures on the destruction of barberry plants in these States are furnished by the Bureau of Plant Industry: During the calendar year 1928, 1,519,816 barberry bushes were found and 1,520,832 were destroyed (including about 1,000 which had been found the previous season). The to-

tal number of barberry bushes, sprouting bushes, and seedlings found since the campaign was started in 1918 is 17,592,224, and the number destroyed is 17,587,276. The first survey of the 13 States concerned is almost completed, and the bureau reports also that about 27 per cent of the area has been covered a second time.

A request for a minor modification in this quarantine so far as it relates to Mahonia, has been received from the central plant board and is being studied with a view to later action.

Ten violations of the quarantine prohibiting the interstate shipment of certain kinds of barberry and Mahonia into 13 Middle-Western grain-growing States, were intercepted and returned to the shipper by inspectors of the administration during the year.

THE WOODGATE RUST

The Woodgate rust is a disease of the Scotch pine and certain other hard pines and has, as now determined, been established for 25 or 30 years in the northern part of New York State. The possible seriousness of this disease to important elements of our remaining pine timber has only been recognized recently, however, and after due notice and public hearing a quarantine on the subject of this disease was promulgated by the Secretary of Agriculture on October 18, 1928. This quarantine prohibits the movement of Scotch pine and certain other hardwood pines from the regulated area. This area includes Clinton, Essex, Franklin, Hamilton, Herkimer, Jefferson, Lewis, Oneida, and St. Lawrence Counties, N. Y. Two heavily infected sections are known, one just southwest of the Adirondack Mountains, and the other in the extreme northeastern corner of the State. The disease is less generally distributed in other parts of the regulated area.

All hard pines appear to show a certain amount of susceptibility to Woodgate rust infection, but several important species (including red and pitch pines) have not yet been proved able to support the fungus long enough to harbor and disseminate the disease, and are therefore omitted from the list of restricted species at this time.

None of the pines now prohibited movement, namely, Scotch, Canary Island, slash, Japanese red, Corsican, stone, western yellow, Monterey, lobolly, and Jersey pines, is native of this region, but several of them have been widely introduced.

Scotch pine, the species attacked with particular virulence, is a tree of great value to the Northeastern States, where it has proved successful when planted in blowing sand. The danger from Woodgate rust, however, lies less in the menace to that species than in the danger of its spreading to other regions and proving highly injurious to the extensive hard pine stands in the Southern and Western States.

The disease causes galls or swellings on the trunks and limbs of the trees attacked. The parts of the tree above the galls then die, or "brooms" are produced which destroy the value of the pine for lumber. This rust is especially difficult to control as it spreads direct from tree to tree without the intervention of an alternate host.

That this disease is an introduction into the New York area seems to be obvious, but its origin, probably in connection with some foreign introduction, has not been determined.

FOREIGN-PLANT QUARANTINES

The enforcement of the restrictions on the entry of plants and plant products under the various foreign quarantines and regulatory orders which have been promulgated by the department for the purpose of excluding new and injurious pests has been continued substantially along the lines discussed in previous reports.

This work is performed by inspectors and collaborators of the administration stationed at the more important ports of entry and its effectiveness was augmented by the splendid cooperation rendered by the customs service and the Post Office and State Departments. Since descriptive matter relating to the various foreign quarantines and regulatory orders enforced in the manner described above is available elsewhere, these quarantines are not discussed in this report except in the summary which has been given yearly of new quarantines and amendments of old quarantines, page 70. A record of the inspection work performed at the various ports of entry and elsewhere in the United States in the enforcement of foreign quarantines and of the importation of restricted plants and plant products follows.

PLANT-QUARANTINE INSPECTION

The enforcement of foreign-plant quarantines and regulatory orders at maritime, interior, and Mexican border ports of entry involves: (1) The inspection of vessels arriving at ports of entry from foreign ports and from Porto Rico and Hawaii; (2) the inspection and disposition of all plants and plant products under restriction found in passengers' baggage by the United States customs officials; (3) the inspection of all plants and plant products, including nursery stock, seeds, bulbs, fruits, and vegetables entered under permit from all foreign countries and localities and certain products arriving from domestic territory; (4) disinfection (fumigation or sterilization) of cotton and broomcorn and other products requiring such treatment as a condition of entry; (5) inspection, in cooperation with customs and post-office officials, of restricted plants and plant products arriving by foreign parcel post; (6) inspection of plants and plant products introduced by the Department of Agriculture and all plants imported under special permit in accordance with the provisions of regulation 14, quarantine 37; (7) field inspection of plants imported under special permit and grown under agreement; (8) inspection of plants (domestic) entering and leaving the District of Columbia; (9) inspection of plant-introduction gardens of the Bureau of Plant Industry; and (10) inspection of fruits and vegetables in the field and at the point of shipment in Porto Rico and Hawaii in accordance with the provisions of quarantines 58 and 13, respectively. In addition, this service inspects and certifies export fruits and vegetables to meet the sanitary requirements of certain foreign countries, and at certain ports assists flour exporters by inspecting the holds of vessels and warehouses for the presence of stored-grain insects.

The establishment of foreign air-transportation lines during the year has increased to some extent the volume of baggage inspection necessary in cooperation with the customs service. Two thousand two hundred and forty airplanes arrived from foreign countries at landing fields located at Brownsville, Tex., Miami, Fla., San Diego, Calif., and San Juan, Porto Rico. Contraband plants and plant products were intercepted on 134 occasions. In addition to the examination, in cooperation with the customs service, of baggage arriving by airplane, the inspectors of the administration also assisted in the examination of baggage arriving on the *Graf Zeppelin* on October 15, 1928. While no contraband plants or plant products were found in the baggage or in the cargo, bouquets of flowers used for decorative purposes in passengers' quarters were found to be infested with seven species of insects and infected with two plant diseases. While the pests intercepted may not represent pests new to the United States, they attract interest in that they were among the interceptions made on the occasion of the first commercial trans-Atlantic voyage in a lighter-than-air ship.

In order to facilitate the inspection and release of plants and plant products imported under permit, and to inspect, in cooperation with customs officials, vessels, trains, etc., arriving after official hours, it was necessary for the inspectors of the administration stationed at various ports of entry to work 7,542 hours overtime, for which it was impossible to grant additional compensation.

The more important features of this inspection work are summarized below.

MEXICAN-BORDER SERVICE

Inspectors are stationed at the following 10 ports of entry along the Mexican border: Brownsville, Hidalgo, Laredo, Eagle Pass, Del Rio, and El Paso, Tex.; Douglas and Nogales, Ariz.; and Calexico and San Ysidro, Calif.

At the seven ports having rail connections with Mexico a total of 36,941 cars was inspected in the Mexican railway yards. Of these, 34,914 cars entered the United States, 16,019 of which were fumigated as a condition of entry. Two thousand four hundred and eighty-eight cars were found to be contaminated with cottonseed and were required to be cleaned before entry was permitted. A charge of $4 is made for each car fumigated, and all fees collected are turned into the Treasury as miscellaneous receipts.

A summary of the railway-car inspection and fumigation is given in Table 12.

TABLE 12.—*Inspection and fumigation of railway cars crossing the border from Mexico, fiscal year 1929* [1]

Port	Cars inspected	Cars with cottonseed	Cars entered	Cars fumigated	Fees collected
Brownsville	437	70	437	176	$704
Douglas [2]	1,599	67	1,599	46	184
Eagle Pass	3,294	750	2,702	2,196	8,500
El Paso	11,056	437	10,684	2,637	11,068
Laredo	10,596	918	9,759	7,927	32,032
Naco [3]	42	0	42	42	168
Nogales	9,917	246	9,691	2,995	12,368
Total	36,941	2,488	34,914	16,019	[4] 65,024

[1] This table does not include work performed at Del Rio. Inspectors at that port inspected 43,546 vehicles of various descriptions, 3 of which were found contaminated with cotton and fumigated as a condition of entry, fees amounting to $1.50 were collected and turned into the Treasury.

[2] Does not include 1,765 loaded Mexican gondolas which crossed to the smelter, unloaded, and returned to Mexico.

[3] The inspectors stationed at Douglas have performed the necessary inspections and fumigations at Naco.

[4] The apparent discrepancy in fees collected and the number of cars fumigated may be explained by the act that it is customary for the railroads to purchase fumigation coupons in advance.

In addition to inspecting and fumigating railway cars and vehicles entering from Mexico, the inspectors of the administration cooperate with the customs service in the inspection of baggage, personal effects, and express packages from the same country. Parcel-post packages from Mexico are inspected in cooperation with the customs service and Post Office Department. During the year under consideration 61,004 pieces of baggage and 3,986 parcel-post packages were examined. As a result of these inspections a large number of prohibited plants and plant products have been intercepted, many of which were found to be infested with the Mexican fruit worm, pink bollworm, and other injurious insects. A list of the plants and plant products intercepted is included in Table 13.

In addition to the considerable quantities of certain fruits and vegetables which are entered for local consumption under the permit issued to the inspector in charge for this purpose, 6,011 cars of tomatoes, green peas, peppers, melons, and other vegetables, and 2,695 cars of bananas consigned to various points in the United States were inspected and permitted entry.

TABLE 13.—*Contraband plants and plant products intercepted at Mexican border ports, fiscal year 1929*

Commodity	Brownsville		Del Rio		Douglas		Eagle Pass		El Paso		Hidalgo		Laredo		Nogales		San Ysidro		Total	
	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number	Interceptions	Number
Apples	316	1,120	35	83	257	515	158	449	446	1,417	215	670	581	2,359	270	913	607	2,967	2,885	10,493
Apricots					10	79	17	407	22	251			36	1,010	15	403	37	470	137	2,620
Avocados	191	739	31	101	3	7	183	743	268	812	109	490	411	2,500	29	62	19	53	1,244	5,507
Avocado seeds	38	141	4	53	2	5			50	135	49	123	82	608	34	1,091	2	2	261	2,158
Cherimoyas	26	41	2	6			5	108	35	61	8	14	30	49	3	18			109	297
Corn (ears)	102	1,002			83	318			141	797									326	2,117
Corn (pounds)	16	428	22	71	76	139	53	264	34	182	50	203	93	414	107	537	1	3	452	2,241
Cotton bolls	49	168			1	1			36	181	33	251	2	6	2	5	4	17	127	629
Cotton lint (pounds)	21	8			7	11	1	3	3	3	4	8	8	21	1	1			45	55
Cottonseed (pounds)	158	53	3	2	5	19			30	24	18	31	7	12					221	141
Dates	15	738					2	54			5	211	2	327	29	4,733	3	184	56	6,247
Figs	24	584	16	867	3	70	176	9,214	96	2,394	18	595	137	2,747	78	2,858	20	202	568	19,531
Grapefruit	249	713			8	18	2	2	13	58	245	729	43	154	22	110	125	479	707	2,263
Guavas	41	214	4	44	13	53	10	45	82	451	13	75	182	1,026	28	328	3	105	376	2,341
Kumquats	12	205							1	5	4	209							17	419
Mamey	57	114	7	12			8	18	98	157	36	54	58	134	2	8			266	497
Mangoes	123	347	18	66	16	30	62	191	306	791	37	94	173	768	89	294			824	2,581
Oranges	642	2,695	74	215	304	859	325	851	574	1,681	594	2,408	1,078	4,568	425	1,838	971	7,423	4,987	22,538
Papayas	19	26									1	1	7	13	4	6			31	46
Peaches	52	251	17	233	60	457	50	346	118	370	26	149	151	1,087	163	825	43	198	680	3,916
Pears	32	87	8	40	14	150	26	43	67	236	14	49	149	691	69	380	73	233	452	1,909
Plants	199	847	43	300	115	540	84	470	142	819	100	710	328	4,531	96	815	50	278	1,157	9,310
Plums	20	237	3	139	14	71	7	58	22	121	9	56	39	326	35	798	16	87	165	1,893
Pomegranates	68	204	14	113	17	34	65	308	47	215	35	77	170	758	161	1,145	15	88	592	2,942
Potatoes	64	651	2	11			32	145	151	2,450	50	498	88	1,139			33	904	420	5,798
Quince	41	131	5	13	10	40	32	100	36	49	33	96	144	489	98	242			399	1,160
Sapotes	1	3	1	1			1	3	25	55	4	6	6	31			1	6	39	105
Seed cotton (pounds)	110	3							15	3	27	59	11	43	12	63			175	171
Sugarcane	53	221	53	136	44	57	74	229	216	277	56	23	129	655	89	264	8	42	722	1,904
Sweet limes	11	23	2	11	42	71	16	136	52	413	16	96	122	1,002	99	661			360	2,413
Sweetpotatoes	18	96	8	76	44	185	37	173	100	986	8	134	41	211	43	258	11	62	310	2,181
Tangerines	60	287							1	4	78	456	16	78	1	9	86	520	242	1,354

MARITIME-PORT INSPECTION

Ship inspection.—The work of ship inspection has been continued along the lines described in previous reports. Ships from foreign ports as well as from Porto Rico and Hawaii are inspected promptly upon arrival for the presence of prohibited plants and plant products in ice boxes, fruit and vegetable lockers, and passengers' and crews' quarters.

Inspectors are now stationed at the more important ports of entry, with the exception of those located in California, Florida, Alabama, Mississippi, Hawaii, and several ports in Porto Rico. Inspection at these ports has been very efficiently performed by State and Territorial officials serving as collaborators of the administration at a very small cost to the department.

Table 14 indicates, by ports, the number of ship arrivals, ship inspections, and the number of ships carrying contraband plants and plant products, either in passengers' or crews' baggage, stores, cargoes, or passengers' or crews' quarters.

TABLE 14.—*Ships inspected during fiscal year 1929*

Port	From foreign ports—						From Hawaii—						From Porto Rico—					
	Direct			Via United States ports			Direct			Via			Direct			Via		
	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband	Arrived	Inspected	With contraband
Astoria [1]	75	19	14	270	36	6	4	1	0	4	4	0	0	0	0	0	0	0
Baltimore	754	672	350	801	771	283	0	0	0	1	1	0	13	13	5	23	23	0
Boston	1,400	1,138	604	341	269	56	0	0	0	1	1	0	19	19	2	0	0	0
Charleston	164	163	115	126	125	53	0	0	0	0	0	0	1	1	1	0	0	0
Chicago	11	4	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galveston	422	422	311	470	452	147	1	1	1	9	9	0	7	7	3	14	12	3
Gulfport [2]	19	18	0	44	43	0	0	0	0	0	0	0	0	0	0	0	0	0
Houston	187	187	21	511	511	13	0	0	0	11	11	0	11	11	0	6	6	0
Honolulu [2]	202	202	97	65	65	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacksonville [2]	180	180	104	129	129	49	0	0	0	0	0	0	13	13	5	0	0	0
Key West [2]	1,045	1,045	306	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Miami [2]	654	654	309	5	4	0	0	0	0	0	0	0	1	1	1	0	0	0
Mobile [2]	287	287	108	369	368	30	2	2	1	0	0	0	8	8	2	7	7	0
Newport News [2]	99	99	37	614	134	134	0	0	0	0	0	0	0	0	0	0	0	0
New Orleans	2,114	2,102	1,452	214	214	96	12	12	6	2	2	2	16	16	5	4	4	0
New York	5,074	4,074	2,182	1,101	901	364	0	0	0	0	0	0	154	129	43	118	117	86
Norfolk	502	461	200	1,325	1,097	320	3	3	2	1	1	1	13	13	9	13	12	0
Pascagoula [2]	3	3	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0
Pensacola [2]	92	92	19	174	174	0	0	0	0	0	0	0	0	0	0	0	0	0
Philadelphia	1,225	1,135	768	926	845	458	1	1	1	2	2	0	27	26	18	0	0	0
Portland, Oreg	211	211	129	347	347	139	4	4	3	2	2	1	0	0	0	0	0	0
Porto Rico	895	895	482	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0
Providence	73	19	19	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
San Diego [2]	1,443	1,443	39	62	62	0	18	18	6	1	1	0	1	1	0	1	1	0
San Francisco [2]	644	644	112	1,350	1,350	155	188	188	43	3	3	0	1	1	0	0	0	0
San Pedro [2]	2,522	2,522	138	411	411	20	75	75	21	0	0	0	1	1	0	0	0	0
Savannah	145	137	93	44	16	3	0	0	0	0	0	0	1	1	1	0	0	0
Seattle	2,588	1,277	496	103	102	38	13	12	5	22	19	6	0	0	0	0	0	0
Tampa [2]	357	357	67	298	298	12	0	0	0	0	0	0	12	12	0	0	0	0
Total	23,387	20,462	8,575	10,125	8,737	2,376	321	317	89	59	56	10	299	273	95	186	182	89

[1] No inspector at Astoria after Oct. 1, 1928.
[2] Collaborators stationed at these ports.

NOTE.—The foreign ship arrivals do not in all cases agree with customs figures. Foreign ships may put in for bunkers and be inspected by inspectors of the Plant Quarantine and Control Administration, but not entered by Customs. On the other hand boats entered at certain small outside ports are included in customs records but not in this report. At ports of San Francisco, San Pedro, and San Diego 128, 65, and 4, respectively, of the ships listed as from foreign ports via United States ports came by way of Hawaii; consequently these ships assume more importance from a pest-risk standpoint than ships from foreign ports via other United States ports.

Cargo inspection.—All importations of plants and plant products subject to quarantine restrictions, with the exception of special-permit plant material imported under regulation 14 of quarantine 37, which was examined in Washington, D. C., or San Francisco, Calif., were inspected at port of entry or port of first arrival. A total of 29,521 shipments was inspected, 29,353 were permitted entry, and 168 were refused entry. (Table 15.)

TABLE 15.—*Inspection of shipments of plants and plant products offered for entry, fiscal year 1929*

Port	Shipments inspected and entered under permit	Shipments refused entry
	Number	*Number*
Astoria [1]	0	0
Baltimore	495	0
Boston	1,959	2
Charleston	226	0
Chicago	411	2
Detroit	204	14
Galveston	157	0
Gulfport [2]	0	0
Houston	56	0
Honolulu [2]	397	28
Jacksonville [2]	2	0
Key West [2]	1,126	2
Los Angeles [2]	30	1
Miami [2]	93	0
Mobile [2]	173	1
Newport News [2]	0	0
New Orleans	2,556	8
New York	15,767	23
Norfolk	213	0
Pascagoula [2]	0	0
Pensacola [2]	2	0
Philadelphia	809	29
Portland, Oreg	84	0
Porto Rico	796	0
Providence	94	0
San Diego [2]	6	0
San Francisco [2]	1,706	0
San Pedro [2]	452	56
Savannah	58	1
Seattle	765	0
Tampa [2]	716	1
Total	29,353	168

[1] No inspector at Astoria after Oct. 1, 1928.
[2] Collaborators are stationed at these ports.

In addition to inspection, certain commodities require disinfection as a condition of entry. Such treatment is given, under supervision of inspectors of the administration, at commercially operated plants. Material requiring such treatment arriving during the year was as follows: Cotton, 328,356 bales (including 4,315 bales of linters) and 860 packages; cotton waste, 37,134 bales and 23 packages; bagging, 710 bales; tree seeds, 8,800 pounds and 239 packages; nursery stock, 31 shipments; European chestnuts, 55,622 containers; and narcissus bulbs, imported under special permit, 12,769,835. Samples of cotton, cotton waste, and linters arriving by parcel post are also treated under similar supervision at commercial and Federal plants. During the year 1,004 such parcels arrived at approved ports other than Washington, D. C.

Considerable time was also devoted to the supervision of the cleaning by importers of products contaminated with objectionable material such as soil, and the inspection of miscellaneous cargoes, where examination was necessary to establish the true status of the shipment.

Inspections of ships' holds and docks for the presence of insects injurious to flour were performed at the ports of New Orleans, Houston, Galveston, Mobile, Pensacola, and Jacksonville. At New Orleans 152 ship and 107 dock inspections were made; at Galveston 67 ship and 6 dock inspections; at Houston 61 ship and 58 dock inspections; at Mobile 26 ship and 41 dock inspections; at Pensacola 8 ship inspections; and at Jacksonville 1 ship inspection.

INSPECTION OF SPECIAL PERMIT AND DEPARTMENTAL IMPORTATIONS

As in previous years, all plants imported under special permit have been inspected in Washington, D. C., and San Francisco. A tabular record of such importations is given on pages 58 and 59. All departmental importations and distributions from Washington, including domestic plants entering and leaving the District of Columbia, are likewise inspected and certified for shipment at the inspection house or in the nursery, freight, express, or post offices. A summary of this work is given in Table 16.

TABLE 16.—*Summary of plants and plant products offered for inspection in the District of Columbia, fiscal year 1929*

Material inspected	Foreign	Domestic	Fumigated	Otherwise treated	Infested with insects	Infected with diseases
Lots of seed (departmental)	3,276	4,597	7,133	322	183	37
Number of plants, bulbs, roots, rhizomes, etc. (departmental)	17,526	135,094	4,595	22,421	[1] 291	[1] 89
Shipments of plants under regulation 14, quarantine 37 (commercial)	1,190		132	155	130	237
Shipments of plants under regulations 3 and 15, quarantine 37 (commercial)	676		443	37	35	22
Containers of domestic plants other than departmental (mail, express, and freight)		11,121				
Shipments of plants for distribution by United States Botanic Garden		4,054				
Shipments of plants by private individuals		1,342	14	52	48	39
Interceptions of plants and plant products referred to Washington	986		537	23	27	14
Cotton samples referred to Washington	15,967		15,967			

[1] Lots.

Field inspection of plants imported under special permit.—Owing to the impossibility of recognizing plant diseases in certain stages of their life histories and detecting the presence of all insects by any practical method of inspection, plants imported under special permit are, in addition to the preliminary examination made in Washington, D. C., and San Francisco, Calif., inspected in the field during two or more growing seasons for the purpose of determining whether any pests escaped attention at the time initial examination was made. This field inspection also enables the department to determine whether the plants are being used for the public-service purpose for which entry was authorized. During the year in excess of 40,000,000 plants distributed in 774 towns located in 40 States, were so examined.

FOREIGN PARCEL-POST INSPECTION

Foreign parcel-post inspection service is performed in cooperation with customs and post-office officials. Parcel-post packages from foreign countries which are found to contain plants or plant products are referred to an inspector of the administration for examination. Foreign packages arriving at ports where there are no representatives of the administration are forwarded by the postal officials to the nearest port at which an inspector is stationed.

Table 17 indicates the number and disposition of foreign parcel-post packages containing plants and plant products which were inspected during the year.

TABLE 17.—*Inspection of foreign parcel-post packages, fiscal year 1929*

Port	Inspected	Refused entry (entire or part)	Diverted to Washington
	Number	*Number*	*Number*
Baltimore	60	13	34
Boston	3,587	118	993
Charleston	2	0	0
Chicago	1,228	399	127
Detroit	3,290	271	220
Honolulu [1]	597	19	1
Jacksonville [1]	91	25	14
Key West [1]	3	0	1
Los Angeles [1] [2]	3,705	159	66
Miami [1]	21	19	1
New Orleans	29	13	14
New York	12,597	474	393
Philadelphia	3,400	265	249
Portland, Oreg.	45	9	27
Porto Rico	29	5	0
San Diego [1]	34	0	1
San Francisco [1]	3,544	94	101
San Pedro [1]	1	1	0
Seattle	337	78	8
Total	32,600	1,962	[3] 2,250

[1] Collaborators are stationed at these ports.
[2] In addition 76 packages were diverted to San Francisco for treatment.
[3] The contents of 219 of these packages were either entirely or partly refused entry.

INSPECTION IN PORTO RICO AND HAWAII

Inspectors of the administration have continued to have charge of the inspection of foreign ships and plants and plant products arriving in Porto Rico. Valuable assistance has been rendered in this work by insular plant quarantine inspectors serving as collaborators of the administration. The inspectors of the administration stationed in Porto Rico have been

charged also with the enforcement of quarantine 58 which governs the movement of fruits and vegetables from that island to the mainland. Inspection of fruits and vegetables has been carried on in the fields, packing houses, and on the docks, and all shipments moving to the mainland have been certified as to freedom from pests. Table 18 shows by month the various fruits and vegetables inspected and certified for shipment.

TABLE 18.—*Fruits and vegetables moving from Porto Rico to the mainland, inspected and certified under quarantine No. 58, July 1, 1928–June 30, 1929*[1]

Item	Inspected and certified during—						
	July	August	September	October	November	December	January
Avocados	21	164					
Bananas	1						
Chayotes							1
Citrons	12					4	
Cucumbers						561	1,049
Dasheens							1
Ginger	85	51			17		28
Grapefruit	12,794	31,168	78,491	5,523½	896	3,818	2,695
Lemons		1	110				
Limes	47	184		5			
Mixed fruit	1	6	2	1	1	83	3
Oranges	172	1,298	5,352	4,648	5,653	964	2,483
Oranges, King							1
Peppers					14	117	200
Pineapples	14,663	20,002	6,547	2,291	7,067	6,329	12,451½
Plantains				1			
Pumpkins	5					5	64
Squash						53	132
Tangerines					6½		470
Tomatoes					438	99	
Total	27,801	52,874	90,502	12,469½	14,092½	12,033	19,578½
Certificates issued	208	275	237	129	163	152	207

Item	Inspected and certified during—					Total
	February	March	April	May	June	
Avocados						185
Bananas						1
Chayotes						1
Citrons						16
Cucumbers	171	54	1			1,836
Dasheens	20	23		1	7	52
Eggplants		33	170			203
Ginger	51	3	18	43	55	351
Grapefruit	1,548	1,257	5,972	2,411	5,784	152,357½
Lemons						111
Limes						236
Mixed fruit	2	1	1	4	1	106
Onions		25				25
Oranges	48	1	35		1	20,655
Oranges, King		3				4
Peppers	386	292	320	234	19	1,582
Pineapples	3,734	7,511	82,025	282,946	62,314	507,880½
Plantains					1	2
Pumpkins	172	81		15	11	353
Squash	118					303
Tangerines						476½
Tomatoes	105		3			645
Watermelons	5	62	63			130
Total	6,360	9,346	88,608	285,654	68,193	687,511½
Certificates issued	153	116	230	438	236	2,544

[1] Bananas by bunches, remainder by containers.

The work in Hawaii relates principally to the enforcement of quarantine 13 on account of the Mediterranean fruit fly and the melon fly, and consists of the field and packing-house inspection and certification of fruits and vegetables destined for the mainland. A summary of the fruits and vegetables inspected and certified appears in Table 19.

As an accommodation to passengers leaving Hawaii for the mainland of the United States a baggage-inspection service is maintained at Honolulu and Hilo. Baggage of passengers leaving on ships plying between Honolulu and mainland ports only is inspected and sealed, thus eliminating delay incident to baggage inspection at destination. Two thousand two hundred and fifty-two pieces of baggage were inspected and sealed during the year.

TABLE 19.—*Fruits and vegetables inspected and certified for shipment from Hawaii to the mainland, fiscal year 1929*

Month	Bananas[1]	Pineapples	Taro	Coconuts	Ginger root	Lily root	Certificates issued
July	12,559	931	97	37	80	272	164
August	19,842	944	33	22	67	454	193
September	13,334	395	389	96	160	331	136
October	15,840	139	1,284	16	77	381	235
November	15,877	621	413	413	192	266	143
December	19,495	1,017	283	473	308	369	157
January	23,055	1,170	18	283	260	325	164
February	13,100	920	28	16	71	357	142
March	13,306	981	1	179	54	298	166
April	13,638	285	37	257	244	280	140
May	10,987	1,325	17	169	197	236	183
June	12,217	1,537	120	9	16	190	154
Total	183,250	10,265	2,720	1,970	1,726	3,759	1,977

[1] Bananas by bunches; the other commodities by containers.

INSPECTION OF PLANT INTRODUCTION AND PROPAGATING GARDENS

As heretofore, plants for distribution by the Bureau of Plant Industry from its field introduction and propagating gardens were inspected and certified prior to shipment. Plants shipped from Mandan, N. Dak., and Chico, Calif., were inspected by officials of the States concerned serving as collaborators of the administration. Those distributed from Chapman Field, Fla., and Savannah, Ga., were examined by inspectors of the administration in cooperation with officials of the States of Florida and Georgia likewise serving as collaborators. Table 20 indicates the number of plants inspected and certified for distribution.

TABLE 20.—*Summary of plants, bud sticks, cuttings, tubers, roots, and seeds examined for distribution from plant-introduction and propagating gardens, fiscal year 1929*

Station	Plants	Bud sticks, cuttings, tubers, and roots	Shipments of seeds
	Number	*Number*	*Number*
Bell	24,758	1,114	----------
Chico	19,700	10,880	297
Chapman Field	6,784	424	308
Savannah	23,410	1,284	16
District of Columbia	8,288	24,948	14,208
Mandan, N. Dak	524,115	----------	----------
Total	607,055	38,650	14,829

PESTS INTERCEPTED

During the fiscal year the inspectors and collaborators of the administration collected on or in imported plants and plant products 535 recognized species of insects and 454 insects which could be assigned to family or genera only, 10 species of nematodes, and 91 recognized species of fungi and bacteria; and in addition several interceptions of nemas and plant diseases which could be classified only to genera. Many of these interceptions were of considerable economic importance.

The West Indian fruit fly (*Anastrepha fraterculus*) was taken in guava and mango from Cuba, mango from Honduras, and mango and sapodilla from Jamaica; the Mexican fruit fly (*Anastrepha ludens*) in avocado, grapefruit, guava, mamey, mango, orange, pomegranate, sapote, and star-apple from Mexico; *Anastrepha serpentina* in sapodilla from Curacao; *Anastrepha striata* in mango from Honduras; *Anastrepha* sp. in mango from Cuba and Jamaica, and sapodilla from Salvador. The melon fly, (*Bactrocera cucurbitae*) was intercepted in string beans from Hawaii. The Mediterranean fruit fly (*Ceratitis capitata*) was taken in peaches from France, pear from Greece, papaya from Hawaii, orange and tangerine from Italy, loquat from Madeira Islands, and pomegranate from Spain. Trypetid larvæ were taken in mandarin from India, orange from Italy, pricklypear from Madeira Islands, quince from Greece, and in a package of sapodilla seed from British Honduras.

The pink bollworm (*Pectinophora gossypiella*) was intercepted in cotton-seed in restricted bagging from Belgium, and in cotton bolls from India, Hawaii, and Mexico. The vine moth (*Polychrosis botrana*) was found in fresh grapes from Italy. The sugar-cane moth borer of India (*Chilo simplex*) was intercepted in rice straw from Japan. Turnips from England, France, Germany, and the Netherlands were infested with the turnip gall weevil (*Ceutorhynchus pleurostigma*). *Brachycerus albidentatus* was taken in garlic from Italy. *Cylas turcipennis* was taken in sweetpotatoes from Japan. Lima and string beans from Cuba were infested with the bean pod borer (*Maruca testulalis*). *Stenoma anonella* was taken in sour sop from Honduras. *Apion carduorum* was taken in artichokes from Italy. The West Indian sweetpotato weevil (*Euscepes batatae*) was found infesting sweetpotatoes from Brazil and Porto Rico and yam from Brazil and Barbados. *Psylliodes chrysocephala* was intercepted in turnips from England, *Palaeopus costicollis* in yams from Jamaica, *Heilipus perseæ* in avocados from the Canal Zone, and *Heilipus* sp. in avocados from the Canal Zone and Honduras. Mango seed from Hawaii was infested with the mango weevil (*Sternochetus mangiferae*). *Balaninus* sp. was found infesting chestnuts from China, Italy, Japan, Spain, and Switzerland. *Laspeyresia splendana reaumurana* was taken in chestnuts from France, Italy, Japan, and Spain; and *Laspeyresia* sp. in chestnuts from Italy and Japan. The lesser bulb fly (*Eumerus strigatus*) was intercepted in onions from Canada, the Netherlands, and Spain; lily from France and the Netherlands; and hyacinth, iris, and narcissus from the Netherlands. *Eumerus* sp. was taken in onions from Germany and the Netherlands, lily from France, hyacinth from the Netherlands, and narcissus from Germany and the Netherlands. *Merodon* sp. arrived with hyacinth from France and the Netherlands and with narcissus from France.

The sorrel cutworm (*Acronycta rumicis*) was intercepted on apple, Mahaleb, and pear from France and Multiflora (rose) stocks from the Netherlands; *Acronycta* sp. on cherry, Myrobalan, pear, and quince stocks from France; and the white tree pierid (*Aporia crataegi*) on apple and plum stocks from France. *Calophasia lunula* was intercepted on apple and pear from France and on Manetti from the Netherlands. The European tussock moth (*Notolophus antiqua*) was found on apple, Mahaleb, Myrobalan, and pear stocks from France and on cherry and rose stocks from the Netherlands. The sawfly (*Emphytus cinctus*) was taken in Manetti from England, France, Ireland, and the Netherlands, and in Multiflora from France. *Empria* sp. (sawfly) was taken in Manetti from Ireland.

The bulb eelworm (*Tylenchus dipsaci*) was intercepted in onion and narcissus from the Netherlands, and in cut flowers, leaves, and seed pods of narcissus from Canada. Grapefruit and oranges from China and limes from India were found infected with citrus canker (*Bacterium citri*). A canker, *Botryosphaeria dothidae*, was intercepted on roses from Switzerland. Water chestnuts from China were infected with *Ceratostomella* sp. The

leaf spot (*Cercospora ricinella*) was intercepted on castor beans from Mexico; *Cercosporella albo-maculans* on Chinese cabbage from Japan; *Colletotrichum falcatum* on sugarcane from Cuba; *Fusicladium orbiculatum* on mountain ash from Germany; *Gymnosporangium japonicum* on Chinese juniper from Japan; *Oidium euonymi-japonici* on *Euonymus* sp. from Japan; *Oospora pustulans* on potatoes from England, Ireland, New Brunswick, and Norway. Oranges from China and Japan were infected with black spot (*Phoma citricarpa*); and grapefruit from Bahamas, Cuba, Formosa, and Porto Rico, and oranges from Argentina, Bahamas, Brazil, Japan, and Peru, showed the presence of melanose (*Phomopsis citri*); *Puccinia allii* infected leek from France and garlic from Algeria and Italy. Chincherichee rust (*Puccinia kalchbrenneriana*) was found on chincherichee from South Africa. Rice from Japan was infected with a smut (*Tilletia horrida*).

A total of 5,461 interceptions of insects and plant diseases was forwarded to Washington for determination by inspectors and collaborators during the fiscal year. In addition, the collaborators in California, Florida, and Hawaii made 2,471 interceptions of insects and 11 of diseases, 346 interceptions of insects and 245 of diseases, and 252 interceptions of insects and 1 of diseases, respectively, which were identified by State and insular authorities. (Table 21.)

TABLE 21.—*Number of interceptions of insects and plant diseases forwarded to Washington for identification, fiscal year 1929*

Port	Cargo		Stores		Baggage		Mail		Quarters		Total	
	Insect	Disease	Insect	Disease	Insect	Disease	Insect	Disease	Insect	Disease	Insects	Diseases
Astoria [1]	0	0	2	1	0	0	0	0	0	0	2	1
Baltimore	26	6	9	12	5	10	0	0	4	0	44	28
Boston	31	5	50	18	43	3	17	0	9	1	150	27
Brownsville	3	0	1	0	26	3	0	0	0	0	30	3
Charleston	102	3	95	75	0	0	0	0	9	2	206	80
Chicago	6	1	0	0	0	0	4	1	0	0	10	2
Cincinnati	3	0	0	0	0	0	0	0	0	0	3	0
Del Rio	1	0	0	0	4	0	0	0	1	0	6	0
Detroit	38	25	0	1	53	17	21	9	0	0	112	52
Douglas	1	0	0	0	2	0	0	0	0	0	3	0
Eagle Pass	4	0	0	0	7	0	0	0	0	0	11	0
El Paso	5	0	0	0	35	2	3	0	0	0	43	2
Galveston	2	0	0	0	0	0	0	0	0	0	2	0
Hawaii	201	0	1	0	53	1	14	0	12	0	281	1
Hidalgo	0	0	0	0	12	3	0	0	0	0	12	3
Laredo	1	0	0	0	9	0	1	0	0	0	11	0
Mobile	3	0	5	0	3	1	1	0	0	0	12	1
New Orleans	292	13	53	35	20	6	1	2	19	5	385	61
New York	647	92	25	8	75	17	37	11	3	0	787	128
Nogales	1	1	0	0	0	0	0	0	0	0	1	1
Philadelphia	395	130	631	130	20	5	174	33	159	25	1,379	323
Portland, Oreg	24	1	3	0	0	0	2	1	0	0	29	2
San Francisco	22	0	0	0	4	0	0	0	3	0	29	0
San Juan	5	0	1	0	2	0	2	0	0	0	10	0
San Pedro	1	0	0	0	0	0	0	0	0	0	1	0
Savannah	1	0	0	0	0	0	0	0	0	0	1	0
San Ysidro	1	1	0	0	2	0	0	0	0	0	3	1
Seattle	91	24	51	25	84	18	11	6	47	7	284	80
St. Louis	0	0	0	0	0	0	2	0	0	0	2	0
Washington, D. C., inspection house	231	193	0	0	3	0	235	146	0	0	469	339
Miscellaneous	6	2	0	0	0	0	0	0	0	0	6	2
Total	2,144	497	927	305	462	86	525	209	266	40	4,324	1,137

[1] No inspector at Astoria after Oct. 1, 1928.

NOTE.—Inspectors stationed in Porto Rico made 53 interceptions of insects and 2 of diseases during their field and packing-house inspection of fruits and vegetables for shipment to the mainland.

INTERCEPTIONS OF PROHIBITED PLANTS AND PLANT PRODUCTS

A total of 19,934 interceptions of prohibited plants and plant products was made during the year. Fourteen thousand four hundred and four of these interceptions were made in baggage, 1,884 in mail, 125 in cargo, 949 in ships' stores, 1,478 in quarters, 998 in appraisers' stores, and 96 in Porto Rican express. Table 22 indicates by port the number of interceptions of contraband plants and plant products.

TABLE 22.—*Number of interceptions of contraband plants and plant products, fiscal year 1929*

Port	In baggage	In mail	In cargo	In stores	In quarters
Astoria [1]	0	0	0	0	0
Baltimore	3	4	1	2	42
Boston	237	160	1	3	4
Charleston	2	0	2	13	32
Chicago	0	414	0	0	0
Detroit	154	302	22	0	0
Galveston	23	0	0	25	2
Gulfport [2]	0	0	0	0	0
Houston	172	0	2	23	0
Honolulu [2]	4,942	34	2	0	0
Jacksonville [2]	1	16	0	49	2
Key West [2]	2,295	0	0	0	0
Los Angeles [2]	0	64	2	0	0
Miami [2]	1,487	10	0	85	427
Mobile [2]	12	0	1	30	33
Newport News [2]	0	0	0	0	0
New Orleans	499	1	4	127	370
New York [3]	2,538	416	28	1	58
Norfolk	0	0	0	0	0
Pascagoula [2]	0	0	0	0	0
Pensacola [2]	0	0	0	24	0
Philadelphia	81	337	20	148	223
Portland, Oreg	1	10	0	1	2
Porto Rico	229	0	1	13	19
Providence	289	0	0	0	0
San Diego [2]	57	0	0	40	24
San Francisco [2]	615	73	26	215	153
San Pedro [2]	92	1	1	114	33
Savannah	0	0	0	0	0
Seattle	666	42	0	0	0
Tampa [2]	9	0	12	36	54
Total	14,404	1,884	125	949	1,478

[1] No inspector at Astoria after Oct. 1, 1928.
[2] Collaborators are stationed at these ports.
[3] In addition 998 interceptions were made in appraisers stores and 96 in Porto Rican express.

RECORDS OF IMPORTS OF RESTRICTED PLANTS AND PLANT PRODUCTS

Under various foreign quarantines certain plants and plant products are restricted as to entry and made subject to inspection and, if necessary, disinfection, for the purpose of excluding various plant diseases and insect pests. Among these restricted plants and plant products are nursery stock, plants and seeds for propagation, fruits and vegetables, grains from certain countries, broomcorn, cotton, cotton waste, cotton wrappings, and cottonseed products. The records of the importations of these articles are indicated in the discussion and tables following.

Importations of nursery stock, plants, and seeds.—The importations recorded in Tables 23 to 27, inclusive, are entered under regulation 3 of quarantine 37, under permits which are made continuing and unlimited as to the quantity that may be imported. The restrictions under this regulation are intended merely to afford opportunity to inspect, and if necessary, to safeguard the products as they are entered. In the case of Table 23, the entries made during the preceding year are also listed for the purpose of comparison, and in Table 27 the bulb entries of the preceding eight years are brought together to show the fluctuation in the entry of different classes of bulbs.

TABLE 23.—*Importation of fruit, rose, and nut stocks, cuttings, and scions under regulation 3, quarantine 37, year ended June 30, 1929*

[Figures indicate number of plants]

Kind of stocks, cuttings, and scions	Arabia	Australia	Belgium	Canada	Chile	China	Czecho-slovakia	Egypt	England	France	Germany	Greece
Apple			100	573			238		2,186	2,223,750		
Apricot		60										
Cherry						39				6,549,550		
Fig											29	10
Grape	16		120	12	107			26		103	330	
Nut				69					33	25,300		
Olive												25
Pear			125						100	1,008,100		
Plum									6	919,700		
Quince			50			16			430	288,750		
Rose									2,880,800	1,498,100		
Total	16	60	395	654	107	55	238	26	2,883,555	12,513,353	359	35

Kind of stocks, cuttings, and scions	Nether-lands	India	Ireland	Italy	Scotland	Switzer-land	Syria	Turkey	Total	
									1928–29	1927–28
Apple				3		7,510			2,234,360	[1] 4,251,221
Apricot									60	
Blackberry										2
Cherry	59,900					1,000			6,610,489	7,103,017
Fig								43	82	56
Grape		50		3,206			85		4,055	27,274
Medlar										200
Mulberry										25
Nut									25,402	24,750
Olive									25	
Peach				3					3	50
Pear						13,000			1,021,325	[1] 1,568,481
Persimmon				2,000					2,000	
Plum	5,000					1,000			925,706	1,028,953
Prune						2,000			2,000	46
Quince									289,246	540,930
Rose	6,466,337		121,100		25,000				10,991,337	10,505,436
Total	6,531,237	50	121,100	5,212	25,000	24,510	85	43	22,106,090	[1] 25,050,441

[1] Errors found in 1927–28 reports and totals corrected accordingly.

TABLE 24.—*Importation of bulbs under regulation 3 of quarantine 37, year ended June 30, 1929*

[Figures indicate number of bulbs]

Bulb	Bermuda	Canada	China	England	France	Germany	Netherlands	India	Ireland	Japan	Philippine Islands	Scotland	Switzerland	Total
Chionodoxa				886			486,342							487,228
Convallaria				412		22,358,825	727,930							23,087,167
Crocus				4,060			9,882,486							9,886,546
Eranthis				124	100		143,368							143,592
Fritillaria				28			115,630							115,658
Galanthus				6,822			711,308							718,130
Hyacinth				24	685,423		20,765,100							21,450,547
Ixia							827,154							827,154
Lily	1,215,582	280	19,523	7,496	758,100	23,732	502,317	1,612	12	18,923,330	1,000	40		21,453,024
Muscari				1,000	100		1,638,882							1,639,982
Scilla				400			1,436,584						4	1,436,988
Tulip		100		276,004	86,650		191,596,408							191,959,162
Total	1,215,582	380	19,523	297,256	1,530,373	22,382,557	228,833,509	1,612	12	18,923,330	1,000	40	4	273,205,178

TABLE 25.—*Summary of bulb importations under regulation 3, quarantine 37, for the years 1922 to 1929*

Figures indicate number of bulbs]

Bulb	1922	1923	1924	1925	1926	1927	1928	1929
Chionodoxa [1]			339,766	465,422	839,637	466,872	439,075	487,228
Convallaria	14,951,170	19,603,092	17,568,835	18,980,311	20,543,785	20,558,460	24,738,880	23,087,167
Crocus	6,319,082	8,286,500	10,815,920	10,624,670	10,898,968	9,969,070	8,775,467	9,886,546
Eranthis [1]			93,314	152,787	214,173	144,150	135,842	143,592
Fritillaria [1]			92,951	104,483	209,543	125,688	111,778	115,658
Galanthus [1]			797,381	895,003	1,128,335	844,544	662,989	718,130
Hyacinth	24,808,236	29,142,797	32,197,740	27,947,261	23,682,560	23,711,178	22,127,888	21,450,547
Ixia [1]			335,158	371,983	545,278	529,404	704,644	827,154
Lily	8,219,460	9,145,630	9,690,486	11,207,559	16,031,090	16,228,762	19,917,477	21,453,024
Muscari [1]			612,329	906,259	1,404,573	993,339	1,150,220	1,639,982
Narcissus	77,270,548	77,193,281	92,659,666	106,314,049	142,384,199	[2]	[2]	[2]
Scilla [1]			994,762	1,742,514	2,012,750	1,553,313	1,341,685	1,436,988
Tulip	64,846,940	76,719,116	92,539,157	96,290,452	106,849,572	129,681,036	161,940,818	191,959,162
Unclassified	70,750	183,900				11,112		
Total	196,486,186	220,274,316	258,737,465	276,002,753	326,744,463	204,816,928	242,046,763	273,205,178

[1] Imported under regulation 14, quarantine 37, from June 1, 1919, to January 1, 1923.
[2] Imported under regulation 14, quarantine 37, since January 1, 1926

TABLE 26.—*Importation of tree seeds under regulation 3, quarantine 37, year ended June 30, 1929*

[Figures indicate number of pounds]

Country of origin	Apple	Apricot	Banana	Cherry	Grape	Nut and palm	Ornamental and tree	Peach	Pear	Persimmon	Plum	Quince	Rose	Miscellaneous	Total
Africa						1	13								14
Austria	475			1,602		72	12,291		100	5	225		1		14,771
Australia						22,158	125								22,283
Brazil						302	71								373
British Honduras							3								3
Canada							3,612								3,612
Canary Islands							20								20
Ceylon			2			8	11								21
China						1,388	2,099	1,100	175	100				1	4,863
Cuba						21	16								37
Czechoslovakia							4,416								4,416
Denmark							1,133								1,133
England						3	2								5
Finland							17								17
France	12,485		11	1,561		104	4,804		893	30				3	19,891
Germany							1,412						95		1,507
Guam				5											5
Netherlands							154								154
Hungary							2								2
India						6	35								41
Italy		8				15	2,383								2,406
Japan				778	3	456	8,910		804	163		36	117		11,267
Mexico			40				48								88
New Zealand						112	362								474
Norway							10								10
Palestine							3								3
Philippine Islands						2	7								9
Poland							135							5	140
Spain							1								1
Switzerland				1											1
Trinidad						144									144
Union of Socialistic Soviet Republics						1	93								94
Yugoslavia							11								11
Total	12,960	8	53	3,947	3	24,793	42,199	1,100	1,972	298	225	36	213	9	87,816

NOTE.—In addition to the seeds above indicated in pounds, 164 packets of miscellaneous seeds were imported from numerous sources. These packets contained seeds ranging in weight from a fraction of an ounce to several ounces.

TABLE 27.—*Distribution by States of bulbs, nursery stock, and seeds imported under regulation 3 of quarantine 37, during year ended June 30, 1929*

State	Bulbs (cases)	Stocks, cuttings, and scions (number)				Seeds (pounds)					
		Fruit	Nut	Rose	Total	Fruit	Nut and palm	Ornamental and tree	Rose	Miscellaneous	Total
Alabama	380	77,000			77,000	100	6	311			417
Arizona	31							1			1
Arkansas	170										
California	6,972	105,449		15,000	120,449	1,334	10,708	1,018	1	3	13,064
Colorado	1,063			69,600	69,600	50		226		1	277
Connecticut	2,398	885,912		1,118,575	2,004,487	26	74	776			876
Delaware	429	50,000		1,500	51,500			1			1
District of Columbia	775	5,036		5,000	10,036						
Florida	94	89		500	589	5	84	135	10		234
Georgia	1,057					100	333	4,959	6		5,398
Idaho	43						1				1
Illinois	24,653	82,555		1,222,700	1,305,255		117	1,016	3		1,136
Indiana	1,937	628,000		1,219,800	1,847,800		37	14			51
Iowa	1,593	2,562,100	2,000	154,900	2,719,000	851		805	5		1,661
Kansas	521	746,000			746,000	8,804		2,357			11,161
Kentucky	719	5,000		15,000	20,000						
Louisiana	199					11	32	8			51
Maine	432							28			28
Maryland	1,996	165,500		27,000	192,500	25		48	1		74
Massachusetts	5,720	6,725		101,600	108,325		42	354			396
Michigan	5,762	232,548		109,100	341,648			235	1		236
Minnesota	1,803			7,500	7,500	12	3	408			423
Mississippi	91							10			10
Missouri	2,263	175,900		45,000	220,900	3,520	107	50			3,677
Montana	129										
Nebraska	546	25,000	1,000	1,000	27,000	10		235	1		246
Nevada	2										
New Hampshire	163							3,360			3,360
New Jersey	9,102	15,030		731,900	746,930	83	1,118	808	90	5	2,104
New Mexico	28	100			100						
New York	70,425	3,984,392	14,300	3,731,625	7,730,317	2,304	6,894	10,994	52		20,244
North Carolina	411	56,000			56,000			23	1		24
North Dakota	100							27			27
Ohio	8,415	666,208	6,000	1,889,837	2,562,045	18	101	991	1		1,111
Oklahoma	347	27,500		7,500	35,000			25			25
Oregon	1,045	44,901	93	12,000	56,994	850		62			912
Pennsylvania	21,339	50,136	2,000	199,850	251,986	1,445	3,665	11,263	41		16,414
Rhode Island	1,636	28,270		66,600	94,870	300		476			776
South Carolina	917										

South Dakota	116	12,000		3,000	15,000						
Tennessee	1,326	165,000		38,250	203,250	4	50	32			86
Texas	629	46,000		24,000	70,000		8	536			544
Utah	346	104,000		5,000	109,000						
Vermont	338										
Virginia	840	38,000	9	27,000	65,009		1,152	77			1,229
Washington	1,841	79,000			79,000	750	37	86			873
West Virginia	531							2			2
Wisconsin	3,105	20,000		101,000	121,000		2	442			444
Wyoming	19										
Exported by permittee	381			40,000	40,000		222				222
Total	185,178	11,089,351	25,402	10,991,337	22,106,090	20,602	24,793	42,199	213	9	87,816

NOTE.—In addition to the seeds above indicated in pounds, 164 packets of miscellaneous seeds were imported from numerous sources and distributed in many of the States. These packets contained seeds ranging in weight from a fraction of an ounce to several ounces.

The record of entry under special permits issued under the provisions of regulation 14 of quarantine 37 for the purpose of keeping the country supplied with new varieties and necessary propagating stock and to meet other technical and educational needs is given in Table 28.

TABLE 28.—*Special-permit importations, 1929, with combined total for the period 1920–1929*

Class of plants	Fiscal year 1929				Total, 1920–1929			
	Permits issued		Importations under permits		Permits issued		Importations under permits	
	Number	Quantity	Number	Quantity	Number	Quantity	Number	Quantity
Gladiolus	178	596,782	170	463,087	1,507	50,487,506	1,250	28,508,843
Dahlia	57	3,835	54	3,757	603	48,136	501	33,586
Iris, rhizomatous	110	7,730	115	8,602	1,253	262,168	1,075	135,281
Iris, bulbous	109	4,723,511	138	4,119,775	1,190	44,997,338	994	31,541,831
Miscellaneous bulbs, roots, etc	152	453,626	138	377,774	1,297	12,490,546	1,024	6,454,665
Peony	91	19,795	82	26,699	1,051	1,368,882	839	659,509
Rose	127	21,776	107	18,905	1,035	216,025	861	155,853
Orchid	165	11,398	160	12,066	1,229	186,620	1,083	140,713
Ornamental	219	151,092	170	121,151	1,449	3,224,951	1,133	2,103,400
Herbaceous	111	59,843	87	49,646	1,162	4,719,759	915	2,927,969
Fruit (trees and small fruits)	11	403	13	350	140	15,050	95	7,011
Narcissus	208	10,929,737	270	12,769,835	896	146,270,646	711	69,047,197
Total	------	16,979,528	------	17,971,647	-------	264,287,627	-------	141,715,858

NOTE.—The disparity in the number of bulbs, plants, etc., imported as compared with the number authorized entry may be explained by the fact that a number of the plants imported during the fiscal year 1929 were entered under permits issued during the fiscal year 1928.

During the year 1,353 such permits were issued authorizing the entry of 16,979,528 plants and bulbs. A total of 17,971,647 plants and bulbs was imported under 1,348 permits as compared with a total of 24,643,420 plants and bulbs imported during 1928. Narcissus importations decreased from 15,869,180 to 12,769,835, bulbous iris from 6,349,134 to 4,119,775, gladiolus from 1,598,697 to 463,087 and orchids from 22,110 to 12,066 as compared with importations of these classes in 1928, while importations of roses increased from 9,460 to 18,905. A summary of special permits issued during the entire period of the quarantine to date is given in Table 29.

The number of varieties considered has now reached a total of 45,939 (an increase of nearly 4,000 during the year), of which 43,949 have been approved for entry. Table 30 shows the distribution of these varieties among the various classes of plants, as well as a comparison of the 1929 importations with those of 1928 for each class. The distribution of the imported special permit material by States is shown in Table 31.

TABLE 29.—*Special-permit importations, yearly totals, 1920–1929*

Fiscal year	Permits issued		Importations under permits	
	Number	Quantity	Number	Quantity
1920	311	10,752,844	171	3,484,195
1921	622	13,965,013	411	8,132,634
1922	750	9,573,199	518	3,344,026
1923	897	15,175,003	719	10,357,406
1924	1,107	15,381,621	862	12,561,306
1925	1,235	9,517,913	1,087	8,575,129
1926	1,445	80,982,954	1,200	6,021,508
1927	1,453	54,006,343	1,256	46,624,587
1928	1,602	37,953,209	1,357	24,643,420
1929	1,353	16,979,528	1,348	17,971,647
Total	10,775	264,287,627	8,929	141,715,858

NOTE.—The disparity in the number of bulbs, plants, etc., imported as compared with the number authorized entry may be explained by the fact that a number of the plants imported during the fiscal year 1929 were entered under permits issued during the fiscal year 1928.

TABLE 30.—*Special-permit material: Number of different varieties of plants requested and approved for fiscal years 1920–1929, and comparison of importations for fiscal years 1928 and 1929*

Class of plants	Varieties of plants requested and approved, 1920–1929			Comparison of importations	
	Requested	Approved	Percentage approved	1928	1929
Gladiolus	1,662	1,528	91.94	1,598,697	463,087
Dahlia	3,075	2,932	95.35	2,881	3,757
Iris, rhizomatous	2,577	2,460	95.46	8,069	8,602
Iris, bulbous	508	507	99.80	6,349,134	4,119,775
Miscellaneous bulbs, roots, etc	2,881	2,858	99.20	604,207	377,774
Peony	2,097	1,854	88.41	24,521	26,699
Rose	4,143	3,728	89.98	9,460	18,905
Orchid	8,803	8,776	99.69	22,110	12,066
Ornamental	12,303	11,644	94.64	98,368	121,151
Herbaceous	6,178	5,978	96.76	54,177	49,646
Fruit (trees and small fruits)	314	301	95.86	2,616	350
Narcissus	1,398	1,383	98.92	15,869,180	12,769,835
Total	45,939	43,949	95.67	24,643,420	17,971,647

TABLE 31.—*Distribution of special-permit material by States for fiscal years 1920–1929*

State	Gladiolus	Dahlia	Rhizomatous iris	Bulbous iris	Miscellaneous bulbs, roots, etc.[1]	Peony	Rose	Orchid	Ornamental	Herbaceous [1]	Fruit [1]	Narcissus	Total
Alabama	14,988			30,980			174		198			6,000	52,340
Arizona	12	14					9	14	2,560			1,000	3,609
Arkansas				18,000									18,000
California	1,922,198	5,984	29,058	10,774,841	54,712	2,272	37,499	34,312	2,081,213	623	232	5,521,253	20,464,197
Colorado	28,494			33,490		150		1,831	5,787	100			69,852
Connecticut	15,879	1,038	1,323	22,745	436	113	31,508	118	151,407	1,292		32,185	258,044
Delaware	2,000		22	169,300		1,016		1,343	5,310	14		28	179,033
District of Columbia	516	166	93	215			320	134	318			26	1,788
Florida	48,860			306,617	84,394		21	86	278,034			6,913,730	7,631,742
Georgia	9,210	360	181	171,485	80				3,075		2	11,696	196,089
Idaho	791		24	2,534	180								3,529
Illinois	3,254,499	95	14,686	881,390	211	44,993	9,947	594	226,638	2	1	221,025	4,654,081
Indiana	2,389,804	186	2,917	502,730	7,010	5,995	2,399	244	30,158	198		1,004	2,942,645
Iowa	112,201		6	10,035	180	24,012			14,295			250	160,979
Kansas		99	2,082	32	90	3,059			475			111	5,948
Kentucky		408		51,200		124		415	3	92		301	52,543
Louisiana	2,500	116		21,750			36	1,332	431			10,363	36,528
Maine	350		40		275	262			902				1,829
Maryland	23,057	439	413	447,075		19,942	500	522	64,348			1,055,863	1,612,159
Massachusetts	3,439,331	1,339	3,414	499,749	2,704	6,478	2,836	24,543	436,471	134		101,680	4,518,679
Michigan	12,374,085	4,453	3,404	1,057,766	7,362	85,809	317	542	572,775	6,715		2,346,663	16,459,891
Minnesota	86,238	49	2,145	99	11	7,445	160	665	35,621			11,000	143,433
Mississippi	6,500	49	9	49,776	5				252			5,175	61,766
Missouri	3,173	249	599	281,211	14	991		4,213	19,645	55		1,226	311,376
Montana	32								100				132
Nebraska	1,132	276				14			351				1,773
Nevada													
New Hampshire	40,053	7	28	21,654	257			31	1,317	5		12	63,364
New Jersey	116,793	5,341	10,053	1,083,169	6,354	39,542	33,479	23,937	2,652,860	9,443	1	488,119	4,469,091
New Mexico				5,000									5,000
New York	2,638,956	4,568	34,037	5,037,141	127,455	218,074	19,606	31,472	3,019,269	28,103	50	12,936,132	24,094,863
North Carolina	769,375	82		3,432,828	10,500			156	751			1,281,305	5,494,997
North Dakota	24,679					7	1						24,687
Ohio	483,555	2,074	20,573	46,868	1,108	126,663	4,421	457	764,752	1,321	64	51	1,451,907
Oklahoma	510			14,000					198				14,708
Oregon	71,942	1,438	1,409	778,954	58,535	2,667	1,406		54,987	134		1,781,991	2,753,463
Pennsylvania	390,168	1,493	2,519	211,993	10,725	51,828	6,796	12,530	253,924	138		3,028,882	3,970,996
Rhode Island	946	1,067	1,557	257,965		5,209	529	157	46,128			226,800	540,358
South Carolina				252,500					3			8,889,490	9,141,993
South Dakota	672		11			2,432	2,300		551				5,966
Tennessee		607	556	193,896		232	87		3,442			832,805	1,031,625
Texas	2,000	1	50	745,671			290	6	76,135	8		7,716,063	8,540,224

Utah	50			30,750					4,747			11,100	46,764
Vermont	11,324		36	8,010		2,359			2,445				24,174
Virginia	20,335	313	3	2,409,304	36	1,399	16	45	44,456			5,249,324	7,725,231
Washington	145,639	1,009	3,533	1,567,158	5,066	3,515	676		159,887	147		[2] 10,095,294	[2] 11,981,924
West Virginia	230			4,000					36				4,266
Wisconsin	55,766	266	500	107,950	74	2,907	520	1,014	49,020	1,122		269,250	488,389
Wyoming													
Total	28,508,843	33,586	135,281	31,541,831	377,774	659,509	155,853	140,713	11,065,275	49,646	350	69,047,197	141,715,858

[1] Prior to 1929 this material was recorded under ornamentals, etc.
[2] Error found in 1927 field report and totals reduced accordingly.

In addition to the foregoing, there was imported from Canada under regulation 15, quarantine 37, a total of 691,475 bulbs, plants, trees, and cuttings as compared with 318,887 during the fiscal year 1928. The total for the fiscal year 1929 includes 6,588 plants, etc., brought in by passengers through border ports where plant quarantine inspectors are stationed.

To authorize the importation of this material 542 permits were issued in 1929, as compared with 441 in 1928 .

Importations of cotton, cotton wrappings, and cotton products.—Tables 32 to 35, inclusive, indicate, respectively, the importations of cotton, cotton waste, bagging, cottonseed, seed cotton, and cottonseed products during the year. The actual number of bales of cotton, cotton waste, and bagging is indicated, but inasmuch as bales vary in size they are referred to as running bales.

In addition to the commercial importations indicated the administration supervised the entry of 901 packages of cotton samples imported by freight or express, 37 cotton-waste samples imported by freight or express, and 16,971 samples of cotton, cotton waste, and linters imported by parcel post.

TABLE 32.—*Importation of running bales of ginned cotton, by country of growth and port of entry, fiscal year 1929* [1]

Country	Baltimore	Boston	Buffalo	Calexico	Detroit	El Paso	Fabens	Galveston	Island Pond	New Orleans	Newport	New York
Algeria		47										
Anglo-Egyptian Sudan		35										
British West Indies												1,240
Chile												331
China		682										1,337
Colombia												660
Dominican Republic												33
Dutch East Indies												2,146
Ecuador												56
Egypt		192,620										13,496
Haiti												2,120
Honduras		20										
India		9,414										52,957
Mexico				90,719		807	1,303					21,548
Nigeria		212										
Peru		1,580										45,224
Porto Rico												1,210
Uganda		30										
United States (continental)	100	1,172	107		3			100	34	39	1,851	14
Total	100	205,812	107	90,719	3	807	1,303	100	34	39	1,851	142,372

Country	Niagara Falls	Nyando	Port Huron	Portland	Richford	Rouses Point	St. Albans	San Francisco	San Pedro	Seattle	Vanceboro	Total
Algeria												47
Anglo-Egyptian Sudan												35
British West Indies												1,240
Chile												331
China				176				26,200		4,891		33,286
Colombia												660
Dominican Republic												33
Dutch East Indies				48				731				2,925
Ecuador												56
Egypt							50					206,166
Haiti												2,120
Honduras												20
India				25				2,861		165		65,422
Japan								13				13
Mexico								2,304	2,395			119,076
Nigeria												212
Peru												46,804
Porto Rico												1,210
Uganda												30
United States (continental)	363	209	1		87	62	876				376	5,394
Total	363	209	1	249	87	62	926	32,109	2,395	5,056	376	[2] 485,080

[1] Includes ginned cotton for immediate export and for immediate transportation and exportation.
[2] Includes 19,404 bales of linters.

TABLE 33.—*Importation of running bales of cotton waste, by country of origin and port of entry, fiscal year, 1929* [1]

Country	Baltimore	Boston	Charleston	Detroit	El Paso	Galveston	Houston	Island Pond	New Orleans	Newport
Austria			225							
Belgium		345								
Canada	42	976		72				99		306
England	49	4,715	3,870			30			1,214	
France		2,465	75						29	
Germany		1,875	21			300	150		77	
Holland	83	2,142	70			9			1	
India		350								
Italy		12								
Japan		75								
Mexico					268					
Russia									7	
Switzerland		1,216					10			
United States (returned)	95	15	38							
Total	269	14,186	4,299	72	268	339	160	99	1,328	306

Country	New York	Philadelphia	Port Huron	Portland	Richford	St. Albans	San Francisco	San Pedro	Seattle	Total
Austria	1,240	79								1,544
Belgium	6,623	147								7,115
Brazil	113									113
Canada			38		163	542				2,238
China	52	5					564		162	783
Czechoslovakia	131									131
England	8,488	1,174		55			20			19,615
France	2,674	1,137								6,380
Germany	4,591	1,029					324			8,367
Holland	8,814	440					100			11,659
India	2,516	1,046								3,912
Ireland	1									1
Italy	2,398	182								2,592
Japan	1,479	855					2,913	375	3,616	9,313
Mexico	2,994	82								3,344
Russia	72	420								499
Scotland	61						20			81
Spain	3,727									3,727
Sweden		23								23
Switzerland	3,291	617					373			5,507
Turkey	10									10
United States (returned)	1									149
Total	49,276	7,236	38	55	163	542	4,314	375	3,778	87,103

[1] Includes cotton waste for immediate export and for immediate transportation and exportation.

TABLE 34.—*Importation of running bales of bagging, by country of origin and port of entry, fiscal year 1929*

Country	Baltimore	Boston	Charleston	Detroit	Galveston	Houston	New Orleans	New York
Algeria								1,269
Australia								3
Austria							374	19
Belgium	8,603	1,010	463		6	30	2,349	10,149
Brazil								26
Canada		1		3,514	55	50		2,059
Cuba						10	2,268	
Denmark	157							903
Egypt		85						
England	1,962	3,175	5,237		1,369	1,004	1,659	9,099
France	1,374	556	76		142	250	2,131	13,975
Germany	5,096	460	2,645		751	726	3,221	1,4320
Greece								219
Netherlands	5,030	3,422	809		3,054		6,319	11,998
India								107
Ireland	86							197
Italy	178	47			1,007	1,398	2,737	6,668
Japan						200		
New Zealand								12
Nicaragua							10	
Portugal								104
Russia			1,100				947	243
Scotland	523	202	47				96	5,306
Spain	201						584	5,832
Sweden								706
Switzerland							53	530
Wales								322
Total	23,210	8,958	10,377	3,514	6,384	3,668	22,748	80,178

Country	Norfolk	Philadelphia	Port Huron	Richford	San Francisco	Sault Ste. Marie	Savannah	Seattle	Total
Algeria		185							1,454
Australia					10				13
Austria							56		449
Belgium	2,496	406					401		25,913
Brazil									26
Canada		22	3,817	43		2,539			12,100
China					1,280				1,280
Cuba									2,278
Denmark									1,060
Egypt									85
England	10,126	5,112					3,446		42,189
France	1,304	403					629		20,840
Germany	8,028	806					352		32,517
Greece									219
Netherlands	7,416	1,985					900		40,933
India									107
Ireland									283
Italy									12,035
Japan					2,582			5,012	7,794
New Zealand									12
Nicaragua									10
Portugal									104
Russia	222								2,512
Scotland	124	594							6,892
Spain	986	4							7,607
Sweden									706
Switzerland		107							690
Wales									322
Total	30,702	9,624	3,817	43	3,872	2,539	5,784	5,012	220,430

TABLE 35.—*Importation, in tons, of cottonseed, seed cotton, and cottonseed hulls, cake, and meal, fiscal year 1929*

Port	Cotton-seed	Seed cotton	Cotton-seed hulls	Cotton-seed cake	Cotton-seed meal
Brownsville				1,418	
Calexico	[1] 498		4,611		
El Paso					597
Fabens				45	403
New York					55
Yuma		[1] 216			
Total	498	216	4,611	1,463	1,055

[1] Entry of cottonseed, seed cotton, and cottonseed hulls grown in the Imperial Valley, Lower California, Mexico, is allowed under permit.

Importations of brooms, broomcorn, and grain.—Tables 36 and 37 indicate, respectively, importations under quarantine 41 of brooms, broomcorn, and clean shelled corn. Importations of clean shelled corn from countries other than those listed in quarantine 24 total 236,306 bushels, practically all of which was imported from Argentina. This quantity shows a marked decrease from last year's importations of 5,117,706¼ bushels. No foreign broomcorn and no seeds, other than corn, of the plants covered by quarantine 41, were imported.

In addition the administration supervised the entry under quarantine 24 of 25,446 bushels of clean shelled corn from Manchuria (7,591 bushels at San Francisco and 17,855 bushels at Seattle) and, under quarantine 55, of 5,032,903 pounds of seed or paddy rice from Mexico.

TABLE 36.—*Importation of brooms and broomcorn, by country of origin and port of entry, fiscal year 1929*

Country	Brooms					Broomcorn (bales)	
	Boston	Brownsville	Laredo	New York	Total	Detroit	Total
Italy	16,100			[1] 2,346	18,446		
Mexico		1,455	420		1,875		
Rumania				25,670	25,670		
United States (returned)						13	13
Total	16,100	1,455	420	28,016	45,991	13	13

[1] 996 brooms transshipped to Colombia.

TABLE 37.—*Importation, in bushels, of clean shelled corn under quarantine 41, by port of entry and country of growth, fiscal year 1929*

Port	Argentina	Bahama Islands	Canada	Chile	France	Mexico	Union of South Africa	United States (returned)	Total
Baltimore	21,597								21,597
Boston	4,894								4,894
Detroit								2,659	2,659
Miami		3							3
New Orleans				2					2
New York	122,766				1		11		122,778
Niagara Falls			51						51
Nogales						3			3
Noyes			2						2
Philadelphia	40,926								40,926
San Francisco	43,391								43,391
Total	233,574	3	53	2	1	3	11	2,659	236,306

Importations of fruits and vegetables.—Tables 38 and 39 indicate the fruits and vegetables imported under permit and inspection during the fiscal year, Table 38 by countries of origin, and Table 39 by ports of entry.

TABLE 38.—*Fruits and vegetables imported during year ended June 30, 1929, by countries of origin*

[Imported under quarantine 56 unless otherwise designated]

Kind	Country and quantity	Total
Apple—pounds	Norway, 20	20
Aralia cordata—do	China, 8,150	8,150
Arrowroot—do	Japan, 1,550	1,550
Asparagus—do	Italy, 30; Mexico, 19,520	19,550
Avocado—do	Chile, 3,000; Colombia (Santa Marta district), 160; Cuba, 4,611,793; Dominica, British West Indies, 300; Dominican Republic, 19,690; Jamaica, 7,460; Mexico (seeds removed), 105,152; Montserrat, British West Indies, 600; St. Lucia, British West Indies, 2,480.	4,750,635
Banana—bunches	Brazil, 20; Colombia, 1,658,176; Costa Rica, 4,643,218; Cuba, 3,277,220; Ecuador, 140; Guatemala, 6,268,672; Haiti, 69; Honduras, 22,102,724; British Honduras, 183,683; Jamaica, 11,437,003; Mexico, 4,482,868; Nicaragua, 3,727,207; Panama (including Canal Zone), 4,569,119.	62,350,119
Bean (green):		
Fava—pounds	Mexico, 20,354	20,354
Lima—do	Cuba, 3,272,748; Mexico, 84,503	3,357,251
String—do	Cuba, 35,593; Mexico, 2,548,679	2,584,272
Beet—do	Bermuda, 16,300; Denmark, 23,500; The Netherlands, 9,470; Mexico, 353,844.	403,114
Berry (Rubus)—do	Norway, 710	710
Broccoli—do	Cuba, 420	420
Cabbage—do	Cuba, 900; Denmark, 383,430; The Netherlands, 5,822,274; Mexico, 34,002.	6,240,606
Cacao bean pod—do	Costa Rica, 100; Panama (including Canal Zone), 89; Trinidad, British West Indies, 150.	339
Carrot—do	Belgium, 3,250; Bermuda, 254,746; Cuba, 400; Denmark, 64,250; The Netherlands, 4,685,971; Mexico, 568,809.	5,577,426
Cassava—do	Cuba, 300,121; Dominican Republic, 3,113	303,234
Cauliflower—do	The Netherlands, 825; Italy, 132; Mexico, 951	1,908
Celery—do	Bermuda, 3,519,004; England, 1,080; Mexico, 1,888	3,521,972
Chayote—do	Cuba, 36,801; Dominican Republic, 1,010; Mexico, 8,937	46,748
Cherry (dried sour)—do	Czechoslovakia, 5,500; Italy, 448,250; Rumania, 166,050; Union of Socialistic Soviet Republics, 24,065; Yugoslavia, 432,435.	1,076,300
Chervil—do	Bermuda, 610	610
Cipollino—do	Italy, 448,016; Morocco (French), 2,200,345; Tunis, 30,110	2,678,471
Citrus medica—do	Greece, 1,389; Italy, 137; Palestine, 28,973	30,499
Clover top—do	Mexico, 1,046	1,046
Cresentia alata—do	Mexico, 150	150
Crosnes—do	Belgium, 1,230	1,230
Cucumber—do	Bahamas, 870; Cuba, 951,994; Mexico, 13,573	966,437
Dasheen (includes colocasia, caladium, inhame, malanga, and taro), pounds.	Azores, 413,338; China, 671,057; Cuba, 527,746; Dominican Republic, 482,829; Japan, 387,439; Mexico, 5,413; Portugal, 3,526; Venezuela, 500.	2,491,848
Eggplant—pounds	Cuba, 6,265,070; Dominican Republic, 40; Mexico, 292,450; Virgin Islands, 4,910.	6,562,470
Endive—do	Belgium, 2,587,822	2,587,822
Fennel—do	Bermuda, 1,620	1,620
Garlic—do	Azores, 266; Canary Islands, 600; Chile, 1,192,033; China, 100; Egypt, 50; Germany, 220,358; Hungary, 13,011; Italy, 1,079,260; Mexico, 1,006,135; Morocco (French), 176; Spain, 1,986.	3,513,975
Ginger (crude)—do	China, 380,345; Costa Rica, 240; Cuba, 9,164; Dominican Republic, 2,010; Japan, 563.	392,322
Grape:		
Fresh (not hothouse), pounds.	Argentina, 4,249,646; Chile, 210,280; Mexico, 297	4,460,223
Hothouse—pounds	Belgium, 492,008; England, 10	492,018
Processed—do	Italy, 18,163	18,163
Grapefruit—do	Bahamas, 2,775; Cuba, 4,832,892; Jamaica, 225,330	5,060,997
Horse-radish—do	Denmark, 400; Germany, 1,386,741; Hungary, 1,773	1,388,914
Husk tomato—do	Mexico, 60,524	60,524
Jicame—do	Mexico, 15,575	15,575
Kale—do	Bermuda, 1,150,038	1,150,038
Kohl-rabi—do	Bermuda, 120; Mexico, 242	362
Kudzu—do	China, 136,578	136,578
Leek—do	Cuba, 1,390	1,390
Lemon—crates	Azores, 1; Cuba, 15; Honduras, 1; Italy, 331,693; Mexico, 12; Syria, 2.	331,724
Lettuce—pounds	Bermuda, 2,360; Mexico, 61,818	64,178
Lily bulb (edible)—do	China, 27,559	27,559

TABLE 38.—*Fruits and vegetables imported during year ended June 30, 1929, by countries of origin*—Continued

Kind	Country and quantity	Total
Lime (sour)—pounds	Antigua, British West Indies, 2,350; Costa Rica, 11,200; Cuba, 425; Dominica, British West Indies, 3,295,039; Dominican Republic, 118,875; Jamaica, 421,663; Mexico, 1,606,674; St. Lucia, British West Indies, 161,900; Trinidad, British West Indies, 2,080.	5,620,206
Melon—do	Argentina, 1,014,394; Chile, 3,690,762: Cuba, 1,530; Italy, 2,487; Mexico, 907,989; Spain, 1,161,779; Turkey, 1,760.	6,780,701
Mint—do	Bermuda, 1,820; Mexico, 3,330	5,150
Mustard—do	Mexico, 44,863	44,863
Nectarine—do	Belgium, 134; Chile, 84,944	85,078
Nuts (in the shell):		
Acorn—do	Greece, 892,953; Italy, 305,000; Turkey, 6,389,425	7,587,378
Chestnut—do	Greece, 6,800; Netherlands, 196; Italy, 19,506,991; Portugal, 25,000; Spain, 65,133.	19,604,120
Okra—do	Cuba, 1,556,823	1,556,823
Onion—do	Australia, 160,910; Azores, 36,074; Bermuda, 3,717; Chile, 8,425,041; Cuba, 1,150; Denmark, 43,069; Egypt, 5,473,296; Netherlands, 35,269,746; Hungary, 274,655; Italy, 4,195,156; Japan, 3,680; Mexico, 1,169,763; Morocco (French), 251,021; Spain, 64,343,059; Union of Socialistic Soviet Republics, 27,500; Virgin Islands, 2,800.	119,680,637
Orange:		
Under quarantine 56, pounds.	Cuba, 68,817; Dominican Republic, 6,860; Jamaica, 82,110	157,787
Mandarin (quarantine 28), pounds.	Japan, 1,754,694	1,754,694
Pachyrhizus—pounds	China, 45,455	45,455
Parsley—do	Bermuda, 635,273; Mexico, 24,583	659,856
Parsnip—do	Mexico, 100	100
Pea—do	Cuba, 307; Mexico, 20,550,557	20,550,864
Peach—do	Belgium, 888; Chile, 5,000	5,888
Pear—do	Chile, 4,000	4,000
Pepino—do	Chile, 300	300
Pepper—do	Bahamas, 4,200; Cuba, 4,479,464; Dominican Republic, 50; Mexico, 7,737,576; Virgin Islands, 580.	12,221,870
Pigeon pea—do	Cuba, 730	730
Pigweed—do	Mexico, 2,011	2,011
Pineapple—crates	Azores, 98; Costa Rica, 4,445; Cuba, 1,067,059; Dominican Republic, 6; Haiti, 1,714; Honduras, 4,079; Jamaica, 2; Mexico, 2,057.	1,079,460
Plantain—bunches	Costa Rica, 1,006; Cuba, 824,366; Dominican Republic, 2,712; Guatemala, 26; Haiti, 35; Honduras, 141,754; British Honduras, 46,058; Jamaica, 101; Mexico, 1,679; Panama (including Canal Zone), 23,023; Venezuela, 14.	1,040,774
Plum—pounds	Argentina, 26,080; Chile, 32,000	58,080
Potato:		
Under quarantine 56, pounds.	Bermuda, 5,488,576	5,488,576
Under potato regulations (order of Dec. 22, 1913), pounds.	Cuba, 4,402,507; Mexico, 426,406	4,828,913
Pricklypear—pounds	Mexico, 12,380	12,380
Pumpkin—do	Cuba, 73,127; Dominican Republic, 43,606; Mexico, 11,438	128,171
Purslane—do	Mexico, 1,348	1,348
Radish—do	Bermuda, 1,530; Cuba, 320; Mexico, 90,094	91,944
Sea onion—do	Denmark, 2,425	2,425
Spinach—do	Mexico, 145,897	145,897
Squash—do	Cuba, 441,017; Mexico, 113,996	555,013
Strawberry—do	Mexico, 387	387
Swiss chard—do	Mexico, 11,238	11,238
Tamarind bean pod—do	Antigua, British West Indies, 38,737; Barbados, British West Indies, 1,000; Mexico, 1,744; St. Kitts, British West Indies, 3,439.	44,920
Tangerine—do	Cuba, 39,830	39,830
Thyme—do	Dominican Republic, 300; Italy, 4,400	4,700
Tomato—do	Bahamas, 7,425,465; Bermuda, 18,835; Chile, 470; Cuba, 26,356,118; Dominican Republic, 45; England, 2,340; Guernsey, Channel Islands, 12,000; Jamaica, 5,010; Mexico, 97,326,182; Virgin Islands, 13,400.	131,159,565
Turnip—do	Bermuda, 4,350; Cuba, 860; Mexico, 357,765	362,975
Vaccinium (cranberry, etc.), pounds.	Newfoundland, 2,897,485; Norway, 522; Sweden, 72	2,898,079
Water chestnut—pounds	China, 1,732,142	1,732,142
Water cress—do	Mexico, 3,602	3,602
Waterlily root—do	China, 39,505; Cuba, 9,168	48,673
Watermelon—do	Mexico, 389,738; Peru, 200	389,938

TABLE 39.—*Fruits and vegetables imported during year ended June 30, 1929, by ports of entry*

[Imported under quarantine 56 unless otherwise designated]

Kind	Port and quantity	Total
Apple——pounds	New York, 20	20
Aralia cordata——do	San Francisco, 8,150	8,150
Arrowroot——do	Seattle, 1,550	1,550
Asparagus——do	New York, 30; San Ysidro, 19,520	19,550
Avocado——do	Boston, 100; Brownsville (seeds removed), 484; Eagle Pass (seeds removed), 10,741; El Paso (seeds removed), 17,796; Hidalgo (seeds removed), 6,603; Key West, 665,555; Laredo (seeds removed), 68,714; Miami, 37,993; New Orleans, 1,387,280; New York, 1,314,961; Nogales (seeds removed), 814; Tampa, 1,239,594.	4,750,635
Banana——bunches	Baltimore, 3,579,615; Boston, 3,507,436; Brownsville, 3,453; Charleston, 940,364; Eagle Pass, 1,889; El Paso, 885,033; Galveston, 872,372; Houston, 4,355; Key West, 14,089; Laredo, 198,977; Los Angeles, 1,396,629; Miami, 199,112; Mobile, 2,365,250; New Orleans, 22,198,870; New York, 18,268,317; Nogales, 72,563; Pensacola, 53,614; Philadelphia, 5,098,020; San Francisco, 1,869,659; Sault Ste. Marie, 250; Savannah, 74,256; Tampa, 745,996.	62,350,119
Bean (green):		
Fava——pounds	Nogales, 20,354	20,354
Lima——do	El Paso, 175; New York, 3,272,748; Nogales, 65,331; San Ysidro, 18,997.	3,357,251
String——do	Brownsville, 185,451; Calexico, 11; Douglas, 3,867; Eagle Pass, 6,726; El Paso, 156,916; Hidalgo, 1,770; Laredo, 1,563,404; New York, 35,725; Nogales, 482,122; San Ysidro, 148,280.	2,584,272
Beet——do	Calexico, 270; Douglas, 11,863; Eagle Pass, 367; El Paso, 330,487; New York, 49,270; Nogales, 10,857.	403,114
Berry (Rubus)——do	New York, 710	710
Broccoli——do	New York, 420	420
Cabbage——do	Boston, 60,000; Calexico, 135; Douglas, 13,034; Eagle Pass, 320; El Paso, 1,307; Laredo, 521; New York, 6,146,604; Nogales, 18,685.	6,240,606
Cacao bean pod——do	New Orleans, 14; New York, 325	339
Carrot——do	Boston, 252,000; Calexico, 1,229; Douglas, 18,410; Eagle Pass, 438; El Paso, 530,744; New York, 4,756,617; Nogales, 17,988.	5,577,426
Cassava——do	Key West, 33,211; New Orleans, 1,500; New York, 227,398; Tampa, 41,125.	303,234
Cauliflower——do	Calexico, 20; Douglas, 208; New York, 957; Nogales, 723	1,908
Celery——do	Douglas, 1,782; El Paso, 83; New York, 3,520,084; Nogales, 23.	3,521,972
Chayote——do	El Paso, 4,592; Key West, 225; Laredo, 4,345; New Orleans, 15,480; New York, 21,746; Tampa, 360.	46,748
Cherry (dried sour)——do	Boston, 102,498; New York, 864,493; Philadelphia, 109,309	1,076,300
Chervil——do	New York, 610	610
Cipollino——do	Boston, 58,054; New York, 2,620,417	2,678,471
Citrus medica——do	Boston, 66; Detroit, 234; New York, 30,188; Portland, 11	30,499
Clover top——do	Douglas, 1,028; Nogales, 18	1,046
Cresentia alata——do	El Paso, 150	150
Crosnes——do	New York, 1,230	1,230
Cucumber——do	Calexico, 80; Douglas, 2,454; Eagle Pass, 115; El Paso, 365; Key West, 785; Laredo, 1,286; Miami, 390; New Orleans, 18,010; New York, 933,469; Nogales, 9,273; Tampa, 210.	966,437
Dasheen (includes colocasia, caladium, inhame, malanga, and taro), pounds.	Boston, 19,249; Calexico, 5,413; Chicago, 2,000; Detroit, 5,000; Key West, 32,738; Los Angeles, 22,000; New York, 1,027,413; Portland, 5,726; Providence, 413,338; San Francisco, 658,187; Seattle, 228,784; Tampa, 72,000.	2,491,848
Eggplant——pounds	Douglas, 678; Eagle Pass, 24,504; El Paso, 935; Key West, 53,905; Los Angeles, 38,823; New Orleans, 943,950; New York, 5,250,550; Nogales, 227,510; Tampa, 21,615.	6,562,470
Endive——do	New York, 2,587,822	2,587,822
Fennel——do	New York, 1,620	1,620
Garlic——do	Boston, 153,505; Brownsville, 3,999; Calexico, 10,995; Douglas, 3,519; Eagle Pass, 3,550; El Paso, 43,332; Laredo, 573,233; New Orleans, 54,478; New York, 2,646,390; Nogales, 3,348; Philadelphia, 17,260; Providence, 266; San Francisco, 100.	3,513,975
Ginger (crude)——do	Boston, 9,462; Chicago, 1,300; Detroit, 1,100; Los Angeles, 6,728; New York, 104,894; Portland, 952; San Francisco, 231,292; Seattle, 36,594.	392,322
Grape:		
Fresh (not hothouse)——do	Eagle Pass, 60; El Paso, 15; Laredo, 175; New York, 4,459,926; Nogales, 47.	4,460,223
Hothouse——do	New York, 492,018	492,018
Processed——do	New York, 18,163	18,163
Grapefruit——do	Boston, 25,970; Chicago, 1,166,620; Cincinnati, 513,240; New York, 3,182,757; Philadelphia, 700; St. Louis, 171,710.	5,060,997
Horse-radish——do	Boston, 3,300; New York, 1,370,990; Philadelphia, 12,397; San Francisco, 2,227.	1,388,914
Husk tomato——do	Brownsville, 5,474; El Paso, 54,928; Hidalgo, 122	60,524
Jicame——do	El Paso, 15,575	15,575

TABLE 39.—*Fruits and vegetables imported during year ended June 30, 1929, by ports of entry*—Continued

Kind	Port and quantity	Total
Kale.....pounds..	New York, 1,150,038	1,150,038
Kohl-rabi.....do....	Douglas, 175; El Paso, 65; New York, 120; Nogales, 2	362
Kudzu.....do....	Boston, 7,060; Detroit, 400; Los Angeles, 15,300; New York, 33,000; Portland, 508; San Francisco, 66,830; Seattle, 13,480.	136,578
Leek.....do....	New York, 1,390	1,390
Lemon.....crates..	Boston, 1,701; El Paso, 12; New Orleans, 43,986; New York, 286,024; Providence, 1.	331,724
Lettuce.....pounds..	Douglas, 14,764; Eagle Pass, 2,072; El Paso, 21,641; New York, 2,360; Nogales, 23,341.	64,178
Lily bulb (edible).....do....	Boston, 3,393; Chicago, 300; Detroit, 300; Los Angeles, 400; New York, 9,784; San Francisco, 8,069; Seattle, 5,313.	27,559
Lime (sour).....do....	Boston, 5,380; Brownsville, 7,840; Eagle Pass, 324,789; El Paso, 49,576; Laredo, 1,096,734; Los Angeles, 112,089; Mobile, 18; New Orleans, 232,644; New York, 3,713,184; Nogales, 4,002; Norfolk, 63,750; San Francisco, 10,200.	5,620,206
Melon.....do....	Boston, 8,750; Brownsville, 300; Calexico, 2,850; Douglas, 320; El Paso, 445; Key West, 1,410; Laredo, 668,356; New York, 5,862,552; Nogales, 235,718.	6,780,701
Mint.....do....	Douglas, 57; El Paso, 3,273; New York, 1,820	5,150
Mustard.....do....	Calexico, 5,952; Douglas, 8,456; El Paso, 25,779; Nogales, 4,676.	44,863
Nectarine.....do....	New York, 85,078	85,078
Nuts (in the shell):		
Acorn.....do....	New York, 7,587,378	7,587,378
Chestnut.....do....	Boston, 814,826; New York, 18,572,859; Philadelphia, 10,846; Providence, 205,589.	19,604,120
Okra.....do....	Key West, 28,495; New Orleans, 877,119; New York, 549,801; Tampa, 101,408.	1,556,823
Onion.....do....	Boston, 5,445,578; Brownsville, 3,263; Calexico, 135; Douglas, 45,401; Eagle Pass, 4,097; Eastport, Me., 300; El Paso, 329,382; Hidalgo, 217; Key West, 1,150; Laredo, 768,100; New York, 112,775,555; Nogales, 19,168; Philadelphia, 83,227; Providence, 40,474; San Francisco, 55,608; Seattle, 108,982.	119,680,637
Orange:		
Under quarantine 56, pounds.	Boston, 22,120; Chicago, 53,480; New York, 81,487; Philadelphia, 700.	157,787
Mandarin (quarantine 28), pounds.	Seattle, 1,754,694	1,754,694
Pachyrhizus.....pounds..	San Francisco, 45,455	45,455
Parsley.....do....	Douglas, 1,095; El Paso, 23,149; New York, 635,273; Nogales, 339.	659,856
Parsnip.....do....	El Paso, 100	100
Pea.....do....	Calexico, 2,744; Douglas, 324; Eagle Pass, 230; El Paso, 4,545; New York, 307; Nogales, 20,463,320; San Ysidro, 79,394.	20,550,864
Peach.....do....	New York, 5,888	5,888
Pear.....do....	New York, 4,000	4,000
Pepino.....do....	New York, 300	300
Pepper.....do....	Brownsville, 12,658; Calexico, 2,218; Del Rio, 10,142; Douglas, 17,894; Eagle Pass, 234,911; El Paso, 604,735; Hidalgo, 1,753; Key West, 18,975; Laredo, 181,370; Los Angeles, 100,662; New Orleans, 260,800; New York, 4,202,414; Nogales, 6,562,138; San Ysidro, 9,095; Tampa, 2,105.	12,221,870
Pigeon pea.....do....	New York, 730	730
Pigweed.....do....	Douglas, 579; Nogales, 1,432	2,011
Pineapple.....crates..	Boston, 5; Eagle Pass, 25; El Paso, 220; Key West, 898,072; Laredo, 75; Los Angeles, 53; Miami, 276; New Orleans, 57,005; New York, 109,804; Nogales, 75; Providence, 98; San Francisco, 80; Tampa, 13,672.	1,079,460
Plantain.....bunches..	Baltimore, 600; Boston, 1,450; Key West, 70,671; Miami, 16,854; Mobile, 171; New Orleans, 71,063; New York, 190,364; Philadelphia, 501,000; San Francisco, 1,006; Tampa, 187,595.	1,040,774
Plum.....pounds..	New York, 58,080	58,080
Potato:		
Under quarantine 56, pounds.	New York, 5,488,576	5,488,576
Under potato regulations (order of Dec. 22, 1913), pounds.	Douglas, 272,680; Key West, 632,286; New York, 3,770,221; Nogales, 153,726.	4,828,913
Pricklypear.....pounds..	Eagle Pass, 400; El Paso, 10,717; Laredo, 1,060; Nogales, 203	12,380
Pumpkin.....do....	Brownsville, 900; Calexico, 166; Douglas, 1,580; Eagle Pass, 2,896; Key West, 28,150; Laredo, 4,338; New Orleans, 220; New York, 79,288; Nogales, 1,558; Tampa, 9,075.	128,171
Purslane.....do....	El Paso, 230; Nogales, 1,118	1,348
Radish.....do....	Calexico, 49; Douglas, 4,468; Eagle Pass, 243; El Paso, 79,001; New York, 1,850; Nogales, 6,333.	91,944
Sea onion.....do....	New York, 2,425	2,425

TABLE 39.—*Fruits and vegetables imported during year ended June 30, 1929, by ports of entry*—Continued

Kind	Port and quantity	Total
Spinach.....pounds..	Calexico, 695; Douglas, 16,581; El Paso, 112,671; Nogales, 15,950.	145,897
Squash.....do....	Brownsville, 75; Calexico, 1,589; Douglas, 7,860; Ealge Pass, 25; El Paso, 49,168; Key West, 3,360; Laredo, 8,734; New Orleans, 24,535; New York, 412,677; Nogales, 19,504; San Ysidro, 27,041; Tampa, 445.	555,013
Strawberry.....do....	El Paso, 387	387
Swiss chard.....do....	El Paso, 11,238	11,238
Tamarind bean pod....do....	New York, 44,920	44,920
Tangerine.....do....	Chicago, 32,830; New York, 7,000	39,830
Thyme.....do....	New York, 4,700	4,700
Tomato.....do....	Brownsville, 22,285; Calexico, 96; Del Rio, 4,435; Douglas, 15,546; Eagle Pass, 8,518,823; El Paso, 340,541; Hidalgo, 2,440; Key West, 5,379,452; Laredo, 816,003; Los Angeles, 6,174,005; Miami, 1,057,947; Mobile, 11,160; New Orleans, 2,878,615; New York, 24,717,390; Nogales, 78,653,154; San Francisco, 2,532,368; San Ysidro, 5,462; Tampa, 29,843.	131,159,565
Turnip.....do....	Calexico, 65; Douglas, 10,552; El Paso, 336,748; New York, 5,210; Nogales, 10,400.	362,975
Vaccinium (cranberry, etc.), pounds.	Boston, 2,153,979; New York, 744,100	2,898,079
Water chestnut.....pounds..	Boston, 57,138; Chicago, 41,000; Detroit, 20,500; Los Angeles, 65,100; New York, 444,800; Portland, 7,500; San Francisco, 798,724; Seattle, 297,380.	1,732,142
Water cress.....do....	Douglas, 2,827; Nogales, 775	3,602
Waterlilly root.....do....	Boston, 4,020; Chicago, 2,000; New York, 9,868; Portland, 400; San Francisco, 17,945; Seattle, 14,440.	48,673
Watermelon.....do....	Calexico, 79,200; Douglas, 1,697; Eagle Pass, 200; Laredo, 150; New York, 200; Nogales, 308,491.	389,938

Plants and plant products entered for immediate exportation or for immediate transportation and exportation in bond.—In addition to the regulated imports for consumption entry recorded in the foregoing tables, the administration supervised the entry under permit, either for immediate exportation or for immediate transportation and exportation in bond, of considerable quantities of plants and p ant products. Among the principal items may be mentioned approximately 1,615,000 bulbs, 97,000 convallaria pips, 634,000 fruit and rose stocks, 35,000 cacti, 16,000 orchids, 10,000 miscellaneous plants, shrubs, and trees, 13,206,000 pounds of citrus fruits, 1,386,000 pounds of potatoes, 2,666,000 pounds of garlic, 27,268,000 pounds of onions, 9,228,000 pounds of tomatoes, 133,071 pounds of cottonseed, 448,600 pounds of cottonseed cake, 2,516,600 pounds of cottonseed meal, 78,610 gallons of cottonseed oil, and 300,364 bushels of clean shelled corn. In addition to the above commodities 60,525 bales of cotton included in Table 21 and 1,510 bales of cotton waste included in Table 22 were reexported.

NEW AND REVISED PLANT QUARANTINES AND MISCELLANEOUS REGULATIONS

The following quarantines and miscellaneous regulations have been either promulgated or revised during the year.

DOMESTIC QUARANTINES

The Asiatic-beetle and Asiatic garden-beetle quarantine was promulgated March 2, 1929, restricting the interstate movement from the State of New Jersey and from the regulated areas of Connecticut, New York, Pennsylvania, and Virginia and the District of Columbia of (1) nursery, ornamental, and greenhouse stock, and all other plants, and (2) sand, soil, earth, peat, compost, and manure.

The European corn-borer quarantine was amended August 7, 1928, by adding certain towns and cities in Hudson County, N. J., to the regulated area, and inserting a requirement that corn and other restricted articles may be moved into the State of Maine from other parts of the regulated areas only under Federal certification; and February 25, 1929, by adding certain territory to the regulated areas, and discontinuing the requirement of certification of packages of shelled corn weighing 2 pounds or less.

The gipsy moth and brown-tail moth quarantine was revised September 6, 1928, by enlarging the area designated as "generally infested" in Vermont, Massachusetts, and Connecticut, and by making provision for interstate movement from the generally infested area of Christmas trees and greens originating in the lightly infested area.

The Japanese-beetle quarantine was revised January 25, 1929, by adding part of one county in the State of Maryland as well as certain new territory in Connecticut, Delaware, and Pennsylvania to the former regulated area, by the establishment of an additional regulated area consisting of the District of Columbia and part of the State of Virginia, and by making certain minor changes in the regulations.

The Mediterranean fruit-fly quarantine was promulgated April 26, 1929, restricting the interstate movement from the State of Florida of (1) fruits, vegetables, and garden and orchard products of all kinds; (2) sand, soil, earth, peat, compost, and manure; (3) railway cars, boats, and other vehicles and containers which have been used in conveying fruits or vegetables; and (4) fruit-packing equipment and all other articles including nursery stock which have been associated with the production of, or commerce in, fruits or vegetables or have been or are contaminated with sand, soil, earth, peat, compost, or manure; it was revised May 9, 1929, by providing for the holding of citrus fruit in approved cold-storage plants after June 15; for the shipment of limes from Monroe and Dade Counties subsequent to June 15; for the use of packing houses in lightly infested zones, when other facilities are absent, for the packing of fruit coming from the surrounding protective zones and adjacent points outside thereof; for the interstate movement under permit of host fruits and vegetables in dining cars, and by prohibiting bulk, mail, and automobile-truck movement of host vegetables from any part of the State; it was amended May 11, 1929, by authorizing the movement under permit of green tomatoes, chili, and Cayenne peppers from infested zones to the District of Columbia and points north and east; it was amended May 16, 1929, by prohibiting the movement of host fruits or vegetables of the crop of 1929 from any part of Florida into the States of Washington, Oregon, Idaho, California, Nevada, Utah, Arizona, New Mexico, Texas, Oklahoma, Arkansas, Louisiana, Tennessee, Mississippi, Alabama, Georgia, North Carolina, and South Carolina, and Porto Rico; it was amended May 23, 1929, by making provision for movement interstate of foreign fruits and vegetables entering the United States through Florida ports, and extending the time for the shipment of noncitrus fruits and host vegetables from protective zones in Florida up to and including June 15, with special provision for shipping grapes up to June 30, 1929; it was amended June 4, 1929, by prohibiting the shipment of nursery stock and all other plants and plant roots by mail from any part of Florida and extending from June 1 to June 15, 1929, the citrus-fruit shipping season from protective zones established subsequent to May 31, 1929; it was revised June 7, 1929, by quarantining each and every State in the continental United States and the District of Columbia and by prohibiting reshipment from noninfested States to the Southern and Western States and territory named above, of host fruits and vegetables originating in an infested State or area; it was amended June 14, 1929, by extending the shipping period for Florida eggplants and peppers to June 30, 1929; and it was amended June 27, 1929, by releasing cowpeas from restriction.

The phony peach disease quarantine was promulgated April 30, 1929, by restricting the interstate movement from the regulated areas of Georgia and Alabama of peach trees, peach roots, nectarine trees, nectarine roots, and all kinds and varieties of trees or shrubs grafted or budded on peach or nectarine roots.

The pink-bollworm quarantine was amended November 2, 1928, by modifying the regulations with respect to the movement of cottonseed and lint, and on May 16, 1929, by releasing a part of the northern half of Dawson County, Tex., from the areas formerly designated as regulated.

The satin-moth quarantine was revised November 21, 1928, by the inclusion of additional territory in the regulated area in the States of Maine, New Hampshire, Vermont, Massachusetts, and Connecticut.

The white-pine blister-rust quarantine was revised July 31, 1928, by providing for the interstate movement under certain precautions and safeguards of 5-leafed pines from the generally infected areas, by removing the prohibition of movement from Wisconsin and Minnesota to Michigan, Pennsylvania, and New Jersey, and authorizing the interstate shipment without Federal permit and without environs inspection of cultivated red and white and mountain currant and cultivated gooseberry plants from infected States, conditioned on their having been dipped in a lime-sulphur solution of specified strength and otherwise complying with the regulations.

The Woodgate-rust quarantine was promulgated October 18, 1928, prohibiting the interstate movement from the regulated area in the State of New York of trees, branches, limbs, or twigs of all varieties of hard pines susceptible to this disease; it was amended March 9, 1929, by adding Madison County to the regulated area.

FOREIGN QUARANTINES

The nursery stock, plant, and seed quarantine was amended July 24, 1928, by prohibiting importation after June 30, 1930, of stocks of apple, pear, quince, and Mazzard cherry and by prohibiting after August 1, 1928, the importation of mango seeds; and on July 26, 1928, by authorizing the entry of the Chinese sacred lily into the territory of Hawaii under permit for forcing purposes.

MISCELLANEOUS REGULATIONS

The rules and regulations governing the movement of plants, plant products, and other quarantined articles into and out of the District of Columbia, were revised March 29, 1929, to bring up to date those parts of the regulations which involved special plant quarantines and to make such minor changes and adjustments as were necessary to define more exactly the District inspection and certification policy.

TERMINAL INSPECTION OF MAIL SHIPMENTS OF PLANTS AND PLANT PRODUCTS

During the year the State of Wyoming inaugurated terminal inspection of mail shipments of plants and plant products under the authority of the act of March 4, 1915, and the list of plants and plant products subject to terminal inspection in Florida, and the terminal inspection points in Wyoming and Mississippi were revised.

California, Arizona, Montana, Florida, Washington, Arkansas, the District of Columbia, Mississippi, the Territory of Hawaii, Utah, Oregon, Georgia, Idaho, and Oklahoma, in the order named, had previously availed themselves of the provisions of the terminal inspection act. While this inspection is conducted entirely at the cost of the States concerned, it has been found of great value in the enforcement of our domestic-plant quarantines.

CONVICTIONS AND PENALTIES IMPOSED FOR VIOLATIONS OF THE PLANT QUARANTINE ACT

The following convictions and penalties imposed for violations of the plant quarantine act were reported to the administration during the year:

White-pine blister-rust quarantine: Six convictions, with fines aggregating $196.

Japanese beetle quarantine: Six convictions, with fines aggregating $256.

Mediterranean fruit-fly and melon-fly quarantine: One conviction, with fine of $25.

Quarantines affecting Mexican products: Fines aggregating $960 were imposed by customs officials on the Mexican border against 187 persons caught attempting to smuggle in from Mexico prohibited plants and plant products.

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REPORT OF THE CHIEF OF THE BUREAU OF PUBLIC ROADS

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF PUBLIC ROADS,
Washington, D. C., September 1, 1929.

SIR: I have the honor to submit herewith the report of the Bureau of Public Roads for the fiscal year ended June 30, 1929, covering the work done in connection with the construction of Federal-aid, national-forest, and national-park roads, the economic and physical researches in connection with problems of highway improvement, and the research and other work of the division of agricultural engineering.

Respectfully,

THOS. H. MACDONALD,
Chief of Bureau.

HON. ARTHUR M. HYDE,
Secretary of Agriculture.

For several years the appropriations authorized for Federal aid in the improvement of the Federal-aid highway system have been $75,000,000 a year. Owing to the fact that the appropriations for the earlier years were not expended within the years for which they were made a balance had been accumulated which has permitted in recent years a rate of improvement greater than would have been possible within the appropriations authorized. This balance has now been absorbed and it has been necessary to confine the program of improvement within the limitations of the appropriations currently authorized.

Accordingly the mileage of improvements completed during the fiscal year 1929 was smaller than in previous years. Initial improvements were completed during the year on only 7,402 miles of the system as compared with 8,184 miles the preceding year. Advanced stages of improvement were completed on 1,987 miles, less by 27 miles than the mileage of similar improvements during the fiscal year 1928. At the close of the year initial improvements were in progress on approximately 8,358 miles and advanced stage construction was under way on 1,167 miles, the corresponding figures a year ago being 9,494 and 1,285 miles, respectively.

All of this work was and is being done on roads included in the Federal-aid highway system which, on June 30 of this year consisted of 188,857 miles of main interstate and intercounty roads.

The total mileage initially improved with Federal aid since the beginning of Federal cooperation is 79,796 miles. Of this mileage a portion, improved prior to 1921, was not included in the Federal-aid system designated in accordance with the Federal highway act passed in that year. In general, the roads omitted from the system were not of sufficient importance to justify inclusion, but having received Federal aid for their improvement the State highway departments have been required by the law to maintain them.

In order to free the States of the necessity of continuing the maintenance of these relatively unimportant roads, arrangements have been made whereby the roads of this character may be abandoned as Federal-aid highways and the Federal funds ex-

pended for their improvement refunded to be reallotted to current projects within the designated system. During the past year approximately 485 miles of such roads have been abandoned, thereby reducing the initially improved mileage of record to 79,311 miles.

By relocations made in the course of stage construction the original length of the improved roads has been reduced by a total of nearly 47 miles, so that the actual present length of the roads initially improved with Federal aid and retained as Federal-aid highways is 79,264 miles. As approximately 1,167 miles were undergoing stage construction at the close of the year and had accordingly been temporarily removed from the classification of improved mileage, the total so classified on June 30, 1929, was 78,096.6 miles.

In addition to the cooperative work carried on under the Federal-aid appropriation, the bureau has also cooperated with the States of Vermont, New Hampshire, Kentucky, Missouri, Arkansas, Louisiana, and Mississippi in the restoration of roads damaged or destroyed by the floods of 1927. This work has been done under special flood-relief legislation enacted by the last Congress; and has resulted so far in the completion of improvements on 21 miles of road in Vermont, 14 miles in New Hampshire, and 29 miles in Kentucky. Other improvements are under way in these States and in the States of the Mississippi Valley above mentioned.

By the completion of 315.4 miles of national-forest roads during the year the total mileage upon which improvements have been completed is increased to 4,090.7. Of this total, 3,782 miles are in the 12 Western States and the Territory of Alaska and 308.7 miles are in Eastern States. These improved roads are portions of the forest road system which has been designated jointly by State and Federal authorities and which includes at present a total of 14,165.7 miles of which 12,014.5 miles are in the 12 Western States and Alaska, and the balance in eastern States.

The work done in improvement of national-park roads under agreement with the National Park Service resulted during the year in the completion of 100.7 miles of important improvements in these reservations including the interesting tunnel section of the Zion Park project and the west-side section of the famous Transmountain Highway in Glacier Park. By the year's addition the mileage of completed improvements in the national parks is brought to 213.4 miles, almost doubling the mileage previously improved. At the close of the year construction was in progress on 113 miles and surveys were under way on 209 miles. All this work is directed toward the eventual improvement of a system of major park roads including 1,509.7 miles.

Among the numerous investigations conducted by the bureau with a view to improving the design of highways and the quality of highway materials, none has produced this year more encouraging results than the studies of soils with respect to their behavior as road subgrades. By the various tests that have been developed it is now believed to be possible to classify the majority of soils encountered in road construction and anticipate their behavior under the conditions to which they are subject as road subgrades; and a report has been issued during the year which outlines definite methods of utilizing this knowledge as a guide in the design of pavements and other road surfaces to be laid on the various types of soil.

Investigations and methods of constructing low-cost bituminous roads are being continued, and information of great value is being obtained and applied in the improvement of portions of the Federal-aid system subject to fairly light traffic and by State and local authorities to other roads of like character outside of the Federal system.

Other physical investigations, especially those relating to the character of Portland cement concrete and the effect of various elements on its quality, have produced important results that have been disseminated in the bureau's publication, Public Roads.

PROGRESS IN FEDERAL-AID ROAD CONSTRUCTION

Initial improvements were completed during the year on 7,402.3 miles of the Federal-aid highway system. Advanced stages of construction were completed on 1,987.7 miles. The total mileage upon which improvements were completed was therefore 9,390 miles.

At the close of the year construction of initial improvement was in progress on 8,358.6 miles, and other initial improvements had been approved for 1,833 miles. Stage construction was

in progress at the close of the year on 1,167.7 miles of road already initially improved with Federal aid, and similar advanced improvements had been approved for 1,065.3 miles.

The year's completion of initial improvements was less than that of any year since 1921 and less than that of the preceding year by 782 miles. The mileage of stage construction completed was greater than the mileage completed in any previous year except 1928, and was less than the record of that year by only about 27 miles. In respect to the total mileage of improvement completed, the year's record was lower than that of all years since 1921 with the exception of 1923 and 1924. The record of mileage completed in each of the fiscal years since 1921 is shown in Table 1.

The decline in mileage completed during the last year is the anticipated result of the shrinkage of the program to the rate fixed by the appropriations of $75,000,000 which have been made for several years past and the absorption of unobligated balance passed on from the earlier years of operation.

TABLE 1.—*Mileage of initial and stage construction completed, by fiscal years, 1917–1921 to 1929, inclusive*

Fiscal year	Mileage of initial construction completed	Stage construction completed		Total construction
		Mileage	Percentage of initial construction	
				Miles
1917–1921	7,469.5	----------	----------	7,469.5
1922	10,247.0	----------	----------	10,247.0
1923	8,820.2	117.8	1.3	8,938.0
1924	8,620.3	360.4	4.2	8,980.7
1925	11,328.6	556.4	4.9	11,885.0
1926	9,417.3	1,052.6	11.2	10,469.9
1927	8,306.9	1,712.6	20.6	10,019.5
1928	8,184.2	2,014.1	24.6	10,198.3
1929	7,402.3	1,987.7	26.9	9,390.0

A year ago the total mileage upon which initial improvements had been completed was 72,394 miles. Up to that time relocations made in the course of stage construction had resulted in the shortening of the original mileage by 34.5 miles, so that the reduced mileage of completed initial improvements was 72,359.5 miles.

During the past year relocations have been completed in the course of stage construction which further reduce the original mileage by 12.2 miles and 485.3 miles improved with Federal aid prior to 1921 and not included in the Federal-aid highway system have been abandoned, as explained subsequently in this report. With these reductions, the addition of 7,402.3 miles of completed initial improvements during the year brings the total of such initial improvements to 79,264.3 miles. With the exception of a small mileage, improved prior to 1921 and still retained, all of this mileage is in the Federal-aid highway system. As 1,167.7 miles of the above total was in course of stage construction when the fiscal year closed, the total mileage classified as improved at that time was 78,096.6, as shown in Tables 16 and 20.

The Federal-aid system, as designated to June 30, 1929, includes 188,857.2 miles of main interstate and intercounty highways. As indicated above, approximately 79,000 miles of the system have been initially improved thus far with Federal aid. While these improvements have been under way with Federal aid the States have been improving other sections without assistance from the Federal Government and their independent work has equalled and perhaps exceeded in volume the work done in cooperation with the Government. A portion of the system was already improved when it was originally designated in 1921. Of the amount of this original improvement and the amount subsequently effected by the independent operations of the States there is no exact record, but a log of the physical condition of the system compiled after inspection of the entire mileage shows that nearly 90 per cent of the system has now been improved to some degree, at least by adequate grading and drainage.

STAGE CONSTRUCTION

As shown by Table 1, stage construction was completed during the year on 1,987.7 miles of the system previously improved with Federal aid. Although this was less than the mileage similarly improved in the preceding year by 26.4 miles, the stage construction this year constituted a greater part of the whole program than in any previous year. Again referring to Table 1, it will be seen that the mileage of stage construction completed this year was 26.9 per cent of the mileage of

initial improvement completed; and it will also be observed that the corresponding percentage has increased progressively year by year since the first work of this sort was done in the fiscal year 1923. As the improvement of the system progresses toward the condition ultimately required it is to be expected that this percentage will continue to increase.

The log of physical condition recently completed indicates that there are now only about 20,000 miles that have not been improved at least by adequate grading and drainage. If the combined efforts of the States and the Federal Government were applied to this unimproved mileage only, it would all be improved in a year or two. It is not likely that this will be done because of the greater need for advanced improvement on other sections of the system. Consequently, there will probably remain for several years some small unimproved sections of the system—the least important of all parts of the system from the standpoint of traffic service.

It does not follow, however, from the fact that substantially the entire system is now or will shortly be improved to some degree, that all Federal-aid work will soon be classed as stage construction. The work so classified includes only the advanced stages of construction on sections of the system originally improved with Federal aid. The first work done with Federal aid on any section of the system is classed by the bureau as initial construction, whether it consist merely of grading and drainage or the construction of a surfaced or paved road. Consequently there is now classified as initially improved with Federal aid a considerable mileage which had been improved by the States to some degree before the first Federal-aid work was done upon it. By virtue of the definition of "initial improvement," as used in these reports, it is to be expected that work so classified will remain for some time an important part of the Federal-aid activity, but it is also to be expected that the type of construction so classified will be higher in the future than it has been in the past.

Since the stage construction is applied to mileage already initially improved with Federal aid it does not increase the initially improved mileage; but, on the contrary, may result in a slight reduction of the original mileage by reason of distance-shortening relocations of alignment. The work of stage construction completed this year, as previously indicated, effects such a reduction amounting to 12.2 miles.

The purpose of the stage construction and its invariable effect is gradually to raise the standard of the roads improved with Federal aid. Because of the pressure of traffic demand and the lack of sufficient funds to improve all parts of the system at once to the standard ultimately required, it has been necessary to limit the initial improvement of the more lightly traveled sections of the system to grading and drainage or to the construction of an inexpensive surface in order to give some measure of improvement to as large a mileage as practicable. As increasing traffic demands and available funds permit these cheaply improved sections are further improved by stage construction, involving usually the construction of a surface where none was built originally or the replacement of a low-type original surface with one of higher type. Occasionally the work involves the correction of alignment or the elimination of railroad grade crossings either by construction of a grade-separating structure or by relocation of the highway to avoid the crossing. In one way or another the effect is gradually to better the existing improvement and this effect is most clearly apparent by comparing the type classification of the improved mileage from year to year.

A year ago, for example, the mileage improved with high-type pavements of brick, concrete, and bituminous concrete was less than 29 per cent of the total improved mileage. Two years prior to that the corresponding percentage was less than 26. To-day 30.4 per cent of the mileage classified as improved (exclusive of bridges) is paved with these highest types of surfacing.

As will be observed in Table 2, 51 per cent of the mileage of stage construction completed during the year was in the West North Central States. Less than 4 per cent was in the sections of the country where population is most dense and traffic heaviest, including the New England, Middle Atlantic, East North Central, and Pacific groups of States. The rest is in the Southern States and the area west of the Mississippi River, mostly in the latter section.

Two factors combine to produce this result: (1) The relative urgency of high-type improvement, and the availability of funds for the purpose; and (2) the extent to which the roads of the various sections had been initially improved without Federal assistance before the designation of the system. Thus, in the sections where traffic is heaviest there has existed for some years an urgent need for road improvement of an advanced type and revenue has been available to carry out such improvement at a reasonable rate. In these sections improvement had been in progress for a considerable period prior to the designation of the Federal-aid system, and a comparatively large percentage of the mileage designated had already been improved to some extent, at least by grading and drainage. The initial Federal-aid improvements in these sections have therefore been of a comparatively high type, and there has been little need to raise their standard by stage construction.

TABLE 2.—*Mileage of stage construction completed during the fiscal year 1929, by groups of States*

Group of States	Mileage of stage construction completed during the year	Percentage of the total
New England	0.3	
Middle Atlantic	8.5	0.4
South Atlantic	182.1	9.2
East North Central	51.7	2.6
East South Central	217.7	11.0
West North Central	1,014.4	51.0
West South Central	241.2	12.1
Mountain	257.5	13.0
Pacific	14.3	.7
All States	1,987.7	100.0

In the other sections, particularly in the region between the Mississippi and the western tier of States, many of the States had made but little progress in road improvement before the Federal-aid system was designated. Traffic at that time was relatively light, and the funds available for construction were, in some cases, extremely limited. With so much of the system entirely unimproved, the first effort was directed toward the extension of some measure of betterment to a large mileage as quickly as possible. Then, as traffic increased, these original improvements have been brought to higher type. In these regions the Federal Government has assisted in the original improvements and is now cooperating in their advancement to higher type; and as would naturally be expected, the advanced improvements constitute the highest percentage of the whole program in the States where the traffic demand is greatest and where there is the nearest approach to completion of the initial improvement of the system. This is preeminently the case in the West North Central States and accounts for the high percentage of the stage construction work that has been done in recent years in this section.

ABANDONMENT OF MILEAGE OUTSIDE OF FEDERAL-AID SYSTEM

Prior to the passage of the Federal highway act in 1921 the law permitted the expenditure of Federal aid upon any road used for the transportation of the United States mails. Although the bureau had requested the States to confine the use of the Federal grants to the improvement of the more important roads, there was no legal means of compelling such a limitation, and some of the money was expended for the improvement of sections of road which were not of sufficient importance to be included in the Federal-aid system when it was designated.

In accordance with the provisions of the Federal law, the States in which such sections existed have since been required to maintain these as well as all other roads constructed in part with Federal aid. None of these sections of road is of sufficient importance to be properly a concern of the Federal Government, and many of them do not justify the attention of the State highway departments. They are actually of local importance and should revert to the jurisdiction of the local authorities.

In recognition of this fact there has been begun a process of abandonment by which in a short time all such roads and sections of roads not now included in the Federal-aid system or likely to be included by any future extension will be dropped from the records of roads built with Federal aid, and the States will be relieved of the responsibility for their future maintenance.

The Federal aid allotted to the construction of these roads is being

charged to other projects currently proposed at the time of abandonment. Thus, in effect—although no actual transfer of funds is required—the States reimburse the Federal Government in the amount of its expenditures upon the roads to be abandoned, and the restored funds are immediately allotted to other projects.

Up to the close of the fiscal year there had been thus abandoned in 18 States 485.3 miles of road, originally constructed at a total cost of $4,734,059.24, of which the Federal Government paid $1,906,542.61. The States in which these roads were abandoned and the mileage, total cost, and Federal aid involved in each State, are shown in Table 3. The mileage of the several types of road abandoned in each of the States is given in Table 4. As will be seen from this table, the greater part of the abandoned mileage had been improved with low-type surfaces.

TABLE 3.—*Total cost, Federal-aid, and mileage of roads abandoned to June 30, 1929, for which other improvements have been substituted*

State	Total cost	Federal aid	Mileage
Alabama	$33,947.60	$16,433.17	5.5
Arkansas	369,863.37	163,645.40	35.2
Kansas	3,084.76	1,542.38	1.5
Louisiana	31,433.22	14,301.06	1.1
Massachusetts	12,150.10	6,075.05	.1
Michigan	357,020.74	163,618.76	20.9
Minnesota	1,319,394.61	491,282.38	178.4
Montana	783.93	391.96	.2
Nebraska	293.68	146.84	.2
Nevada	10,046.35	5,023.17	
New Mexico	52,715.38	25,964.81	9.9
New York	43,692.89	18,245.34	1.1
North Dakota	42,372.46	20,968.87	7.1
South Carolina	4,779.96	2,294.32	
Texas	99,290.75	33,333.34	7.4
Virginia	236,358.30	99,198.03	8.9
Wisconsin	2,104,922.58	838,916.92	197.4
Wyoming	11,908.56	5,160.81	10.4
Total	4,734,059.24	1,906,542.61	485.3

TABLE 4.—*Mileage of roads abandoned to June 30, 1929, for which other improvements have been substituted, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound macadam	Bituminous macadam	Bituminous concrete	Portland cement concrete	Bridges	Total
Alabama			5.5						5.5
Arkansas			32.0		3.0		0.1	0.1	35.2
Kansas	1.5								1.5
Louisiana			1.1						1.1
Massachusetts								.1	.1
Michigan			14.4	2.6		3.9			20.9
Minnesota	17.2		155.7				5.5		178.4
Montana	.1		.1						.2
Nebraska	.2								.2
Nevada									
New Mexico			9.9						9.9
New York							1.1		1.1
North Dakota	6.8							.3	7.1
South Carolina									
Texas			7.4						7.4
Virginia				1.4	7.5				8.9
Wisconsin	49.5	28.5	100.6				18.7	.1	197.4
Wyoming	10.4								10.4
Total	85.7	28.5	326.7	4.0	10.5	3.9	25.4	.6	485.3

The status and character of the new projects upon which the refunded Federal aid has been reallotted are reported fully in Tables 5, 6, 7, 8, 9, and 10. It is shown in these tables that $1,467,699.15 of the refunded total has been allotted, together with additional Federal funds in the amount of $1,746,041.23, as Federal aid in the construction of 198.6 miles of initial improvement and 42.3 miles of stage construction that was completed by the end of the fiscal year at an estimated total cost of $7,867,888.21. These new improvements are shown by Tables 6 and 7 to be predominantly of the higher types. The balance of the Federal expenditure returned, amounting to $438,843.46, has been reallotted in conjunction with an additional sum of $1,452,460.09 to 153.7 miles of initial improvement and 7.6 miles of stage construction which at the close of the year was still under construction. The estimated total cost of these projects, as shown in Table 8, is $4,081,922.16. Their type classification is shown in Table 9.

TABLE 5.—*Total cost, Federal aid substituted, additional Federal aid allotted, and initial and stage mileage of substituted improvements completed to June 30, 1929*

State	Estimated total cost	Federal aid substituted	Additional Federal aid allotted	Mileage	
				Initial	Stage
Arkansas	$1,329,227.26	$54,178.30	$601,174.42	23.1	
Michigan	157,819.35	13,800.15	58,940.85	3.8	
Minnesota	1,974,882.84	491,282.38	74,082.43	40.4	6.6
Montana	26,261.68	92.64	11,179.68	2.0	
New York	425,000.00	18,245.34	125,355.00	9.5	
North Dakota	33,795.54	16,575.23		9.4	
Texas	451,779.61	33,333.34	179,177.28		18.1
Virginia	348,235.08	89,031.06		7.1	
Wisconsin	3,102,728.26	745,999.90	696,131.57	103.3	7.8
Wyoming	18,158.59	5,160.81			9.8
Total	7,867,888.21	1,467,699.15	1,746,041.23	198.6	42.3

TABLE 6.—*Mileage of completed initial improvements substituted for abandoned roads to June 30, 1929, by types of construction, by States*

State	Graded and drained	Gravel	Water-bound macadam	Bitu-minous macadam	Portland cement concrete	Bridges	Total
Arkansas	3.9				18.3	0.9	23.1
Michigan					3.8		3.8
Minnesota	7.6				32.8		40.4
Montana		1.8			.2		2.0
New York					9.5		9.5
North Dakota	9.4						9.4
Virginia				7.1			7.1
Wisconsin		22.6	4.0		76.5	.2	103.3
Total	20.9	24.4	4.0	7.1	141.1	1.1	198.6

TABLE 7.—*Mileage of completed stage improvements substituted for abandoned roads to June 30, 1929, by types of construction, by States*

State	Graded and drained	Gravel	Portland cement concrete	Total
Minnesota	6.6			6.6
Texas			18.1	18.1
Wisconsin			7.8	7.8
Wyoming		9.8		9.8
Total	6.6	9.8	25.9	42.3

TABLE 8.—*Total cost, Federal aid substituted, additional Federal aid allotted, and initial and stage mileage of substituted improvements under construction on June 30, 1929*

State	Under construction				
	Estimated total cost	Federal aid substituted	Additional Federal aid allotted	Mileage	
				Initial	Stage
Alabama	$177,438.51	$16,433.17	$72,286.08	16.6	
Arkansas	349,232.26	109,467.10	65,149.03	15.4	
Kansas	78,417.02	1,542.38	19,844.08	11.1	
Louisiana	876,678.13	14,301.06	424,038.00	3.6	
Massachusetts	245,104.53	6,075.05	69,410.72	4.8	
Michigan	762,940.86	149,818.61	186,921.39	23.5	
Montana	201,469.62	299.32	113,732.48	16.6	
Nebraska	5,557.42	146.84	2,631.87	.9	
Nevada	43,746.45	5,023.17	33,845.54	6.3	
New Mexico	248,008.86	25,964.81	131,735.75	7.8	
North Dakota	124,287.92	4,393.64	49,494.35	23.6	
South Carolina	254,973.03	2,294.32	45,000.00		7.6
Virginia	123,398.35	10,166.97	47,293.82	3.7	
Wisconsin	590,669.20	92,917.02	191,076.98	19.8	
Total	4,081,922.16	438,843.46	1,452,460.09	153.7	7.6

TABLE 9.—*Mileage of initial improvement under construction on June 30, 1929, substituted for abandoned roads, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Bituminous macadam	Bituminous concrete	Portland cement concrete	Bridges	Total
Alabama	16.5						0.1	16.6
Arkansas						15.4		15.4
Kansas	11.0						.1	11.1
Louisiana							3.6	3.6
Massachusetts				4.8				4.8
Michigan			3.0			20.5		23.5
Montana			16.6					16.6
Nebraska		0.9						.9
Nevada				6.3				6.3
New Mexico			4.0		2.9	.4	.5	7.8
North Dakota	23.5						.1	23.6
Virginia				3.7				3.7
Wisconsin			3.9			15.6	.3	19.8
Total	51.0	.9	27.5	14.8	2.9	51.9	4.7	153.7

NOTE.—The only mileage of stage improvement under construction on June 30, 1929, substituted for abandoned roads is 7.6 miles of Portland cement concrete in South Carolina.

TABLE 10.—*Comparison of the abandoned and substituted mileages on June 30, 1929, by States*

State	Abandoned	Substituted	Changes in the mileage of roads improved with Federal aid	
			Increase	Decrease
Alabama	5.5	16.6	11.1	
Arkansas	35.2	38.5	3.3	
Kansas	1.5	11.1	9.6	
Louisiana	1.1	3.6	2.5	
Massachusetts	.1	4.8	4.7	
Michigan	20.9	27.3	6.4	
Minnesota	178.4	40.4		138.0
Montana	.2	18.6	18.4	
Nebraska	.2	.9	.7	
Nevada	(1)	6.3	6.3	
New Mexico	9.9	7.8		2.1
New York	1.1	9.5	8.4	
North Dakota	7.1	33.0	25.9	
South Carolina	(1)	(2)		
Texas	7.4	(2)		7.4
Virginia	8.9	10.8	1.9	
Wisconsin	197.4	123.1		74.3
Wyoming	10.4	(2)		10.4
Total	485.3	352.3	99.2	232.2

[1] Less than 0.1 mile.

[2] Stage improvement substituted.

TYPES OF FEDERAL-AID ROADS

The 7,402.3 miles of initial improvement completed during the year consists of 2,198.1 miles of graded and drained earth roads, 478.5 miles of sand-clay roads, 1,755.5 miles of gravel roads, 85 miles of water-bound macadam roads, 380.8 miles of bituminous macadam roads, 132 miles of bituminous concrete pavement, 2,284.9 miles of concrete pavement, and 43.9 miles paved with brick. The remaining 43.6 miles were made up of numerous bridges and their approaches, each structure more than 20 feet in length.

If the ratio of registered motor vehicles in each State to the mileage of the Federal-aid highway system be taken as a rough measure of the general density of traffic on the system, it will be seen from Table 11 that the types of improvement completed during the year are generally consistent with the density of traffic in each geographic subdivision of the United States, with the exception of the Pacific States. In this table it is

shown that the higher types, including the pavements and bituminous macadam, which are the types best suited to heavy and dense traffic, are represented in greatest proportion in the mileage completed in the Middle Atlantic States where traffic is heaviest; and that the proportion of these types in other divisions, with the exception of the Pacific group, is roughly consistent with the traffic factor.

TABLE 11.—*Relation of the types of initial improvements completed during the fiscal year 1929 and the general density of motor-vehicle traffic on the Federal-aid highway system, by groups of States*

Group of States	Number of motor vehicles per mile of Federal-aid system [1]	Percentage of mileage of initial improvements completed	
		Bituminous macadam and higher types	Water-bound macadam and lower types
Middle Atlantic	384	87.3	12.7
New England	255	80.8	19.2
Pacific	220	43.3	56.7
East North Central	214	78.2	21.8
South Atlantic	103	63.7	36.3
West South Central	89	35.4	64.6
East South Central	79	24.0	76.0
West North Central	70	14.0	86.0
Mountain	39	13.0	87.0
All States	129	38.8	61.2

[1] As registered in the several States during the calendar year 1928.

While in the initial improvements completed during the year the pavement types and bituminous macadam constituted only 38.8 per cent of the total, the net increase of these types, as indicated by Table 27, was 55.6 per cent of the total net increase in mileage, exclusive of bridges, during the year. The difference here noted is the combined effect of stage construction and the substitution of higher types of improvement for the abandoned improvements outside of the Federal-aid system.

As shown by Table 12, the net increase in the mileage of Portland cement concrete pavements was greater than the increase of any other type of improvement; and this table also shows that the increase of the four higher types of improvement was 15.7 per cent as compared with 6.7 per cent for the four lower types, and a general increase of 9.9 per cent.

Of the 78,096.6 miles classified as improved with Federal aid at the close of the year, 11,667.6 miles were graded and drained earth roads, 7,033.3 miles were sand-clay roads, 28,991.1 miles were gravel roads, 1,615.7 miles were water-bound macadam roads, 4,844.8 miles were bituminous macadam roads, 2,193.8 miles were paved with bituminous concrete, 20,617.6 miles were Portland cement concrete pavements, and 865.8 were paved with brick and other block. The remaining 266.9 miles consisted of bridges, each over 20 feet in span, and their approaches.

TABLE 12.—*Mileage of the several types of Federal-aid roads improved at the close of the fiscal years 1928 and 1929 and percentage of increase*

Type	Mileage at close of fiscal year		Percentage increase during fiscal year 1929	
	1928 [1]	1929 [1]		
Graded and drained	10,611.3	11,667.6	9.9	
Sand-clay	6,470.9	7,033.3	8.7	6.7
Gravel	27,698.3	28,991.1	4.7	
Water-bound macadam	1,426.6	1,615.7	13.2	
Bituminous macadam	4,317.2	4,844.8	12.2	
Bituminous concrete	1,993.3	2,193.8	10.0	
Portland cement concrete	17,516.3	20,617.6	17.7	15.7
Brick	817.9	865.8	5.9	
Total	70,851.8	77,829.7	9.9	

[1] Mileage under stage construction at the close of the year and reduction in mileage by relocation, abandonments, etc., deducted from total mileage completed.

EFFECT OF INCREASED TRAFFIC ON ROAD DESIGN

Ten years ago the total number of motor vehicles registered in the United States was approximately 7,500,000. To-day the number in use exceeds 25,000,000, and the number registered in the four States of New York, California, Ohio, and Pennsylvania practically equals the registration in the entire country in 1919. As late as 1921, when the Federal-aid highway system was designated, there were less than 10,500,000 registered motor vehicles in the whole country. It will be seen, therefore, that while the States and the Federal Government have been carrying on their cooperative program of improvement of the Federal-aid system the traffic served by the system has been increasing at a very rapid rate and is now in all probability at least two and a half times as dense as

it was when the work of improvement began.

Naturally, so great an increase in traffic has greatly modified the requirements of road design in all parts of the country. With respect to the Federal-aid system the traffic conditions now existing in such States as Colorado, Utah, Arizona, and New Mexico require a type of improvement equivalent to that required in many of the Eastern States in 1921, and traffic in the more populous industrial States of the East has increased from that represented by an average motor vehicle registration of 152 per mile of the system to the density corresponding to a registration of 382 per mile.

Moreover, these increases in the density of travel on the country's most important roads have been accompanied by corresponding increases in the traffic on the local roads of all sections, so that thousands of miles of these roads now require for the proper accommodation of their traffic a degree of improvement which in 1921 was required only on the main roads.

With respect to the Federal-aid system, these increased traffic demands are being met, as previously stated by stage construction carried on concurrently with the extension of new improvement; but the improvement of the system as a whole is yet far from the standard that will ultimately be required in all sections, and lags behind the present need in most. These roads still remain the most important roads of the country; and although the utilization of all roads has increased, this limited system still serves the preponderance of the traffic. Its further improvement to the higher standard required, therefore, still remains the most important task, and the only task which is of concern to the Federal Government.

The problem of meeting the increased demands of traffic on the local roads is a matter of concern to the local and State governments, and there is evidence in the laws recently enacted by State legislatures that this matter is being given attention by the State governments. Such evidence is found in the application of a portion of the gasoline-tax revenue to local road purposes and in the laws recently enacted and proposed to give supervisory control over such roads to the State highway departments.

On all roads, and especially the important routes included in the Federal-aid system, solution of the problems raised by the increased traffic is not provided merely by the building of higher types of surfaces. A general widening of the surfaces is also required, and, in view of the greater speeds now customary and legally permissible, the easing and superelevation of curves, the cutting away of banks which obscure vision, and other improvements in detail which contribute to safety. The elimination of dangerous railroad grade crossings is an expensive but urgently required improvement, and on the more densely traveled roads it is already desirable to separate the grades of intersecting highways.

For the accomodation of heavy traffic the general types of pavement that have been developed have proved satisfactory. There is constant need, however, for improvement in the details of design and construction, not only to increase their strength and durability, but also to reduce costs and insure uniform excellence of construction. One of the notable recent improvements in the design of concrete pavements is the use of a raised edge which both strengthens the edge of the pavement and serves to prevent the dangerous and costly wearing down of shoulders.

In the construction of concrete pavements it is found also that much more uniform results are obtained by proportioning the fine and coarse aggregates by weight and by taking special precautions to maintain a uniform size grading of the coarse aggregate. This improvement has not yet been adopted by all State highway departments, but the bureau is taking every opportunity to impress its desirability upon those that have not yet adopted it, and will probably insist upon it in the projects undertaken hereafter.

For the roads that serve a somewhat lighter traffic the method of constructing a dustless, and relatively wear-resisting surface by mixture of bituminous material with fine crushed stone in place on the road continues to give very satisfactory results.

BRIDGE CONSTRUCTION

The bridges completed during the year, with their approaches, have an aggregate length of 43.6 miles. The bridges under construction and approved for construction at the end of the year have, with their approaches, a total length of 60.1 miles.

Including the structures just completed, the Federal-aid bridges now

standing have a total length, with their approaches of 266.9 miles.

A list of the bridges completed during the year which cost $75,000 or more is given in Table 13. These, the longest and most expensive of the projects completed, vary in length from about a tenth of a mile to upwards of 2 miles, and have an aggregate length, with their approaches, of 16.3 miles. The rest of the mileage completed is made up of numerous smaller and less expensive bridges, all more than 20 feet in span.

TABLE 13.—*Federal-aid bridges completed during the fiscal year 1929 at a cost of $75,000 or more each*

State	Location	Stream or railroad	Estimated total cost	Length of bridge and approaches
				Miles
Arkansas	At Dardanelle	Arkansas River	$587,600	0.4
Do	At Batesville	White River	348,200	.6
Do	Between Batesville and Tina	Ramsey Bottoms	216,500	.9
Do	At Marked Tree	St. Francis River	128,600	.3
California	Between Califa and Fresno	San Joaquin River	207,600	.2
Do	Near Orick	Redwood Creek	91,000	.1
Do	Near French Camp on Haywards-French Camp Road.	San Joaquin River	227,400	.4
Colorado	Near Swink on Pueblo-La Junta Highway.	Underpass, Atchison, Topeka & Santa Fe Railroad.	85,900	.3
Connecticut	At Saybrook	Overhead bridge over New York, New Haven & Hartford Railroad.	108,600	.5
Do	Between Groton and Preston	Poquetanock Cove	189,300	.3
Do	Between Watertown and Thomaston.	Over Naugatuck River, trolley tracks and New York, New Haven & Hartford Railroad.	357,500	.7
Do	At Windsor Locks	Bridge over New York, New Haven & Hartford Railroad.	120,300	.7
Florida	Between Jacksonville and Kingsland, Ga.	St. Marys River	188,200	.1
Idaho	Between Idaho Falls and Irwin	Snake River	84,500	.1
Indiana	Between Petersburg and Washington.	East Fork of the White River	202,700	.2
Kentucky	Near Shelbiana	Levisa Fork of Big Sandy River and Chesapeake & Ohio Railroad.	100,800	.1
Louisiana	At Clayton	Tensas River	161,200	.1
Do	Between New Orleans and Slidell	The Rigolets	122,900	2.2
Michigan	At Adrian	Underpass, Detroit, Toledo & Ironton Railroad.	90,200	.2
Minnesota	Trunk No. 5, near Shakopee	Minnesota River	144,300	.1
Missouri	Between Chillicothe and Utica	Grand River	131,600	.3
New Mexico	Near Albuquerque on Albuquerque-Isleta Road.	Rio Grande River	137,700	.5
Do	At Las Cruces	Viaduct over Atchison, Topeka & Santa Fe Railroad.	99,100	.2
New York	Between Moscow and Geneseo	Genesee River	102,900	.1
North Carolina	At Washington	Pamlico River	210,500	.2
North Dakota	At Chaloner's Ferry	Little Missouri River	101,200	.1
Ohio	At Ashtabula	Ashtabula River	388,900	.3
Oklahoma	Between Snyder and Altus	North Fork of Red River	238,100	.4
Do	Between Shawnee and Seminole County line.	North Canadian River	93,300	
Oregon	At Springfield	Willamette River	158,700	.5
Pennsylvania	On Tionesta-Irvine Road	Allegheny River	165,700	.1
South Carolina	Between Newberry and Winnsboro.	Broad River	182,900	.3
Do	Between Georgetown and McClellanville.	Santee River	361,300	2.2
Do	Between Whitmire and Chester	Broad River	126,200	.3
Do	Between Columbia and New Brookland.	Congaree River	531,200	.3
Tennessee	Between Memphis and Brownsville.	Wolf River	156,900	.6
Do	Between Dyersburg and Ripley	South Forked Deer River	140,400	.5
Texas	Near Houston on State Highway route No. 3.	San Jacinto River	110,100	.2
Do	Between Vernon and Quanah	Pease River	114,500	.3
Virginia	At Courtland	Nottoway River	89,200	.2
West Virginia	At Cotton Hill Station	Over Chesapeake & Ohio Railroad and New River.	160,000	.2

EFFECT OF RECENT FEDERAL LEGISLATION

The amendment of the Federal highway act approved May 21, 1928, provides that in the case of any State containing unappropriated public lands and nontaxable Indian lands exceeding 5 per cent of the total land area of the State in which the population does not exceed 10 per square mile, the Secretary of Agriculture may increase the share payable by the United States up to and including the whole cost of projects on the Federal-aid primary system and of projects on the secondary system when the latter is a continuation of a route of the primary system or directly connects with a route of the primary system of an adjoining State, It is further provided that where the Federal expenditure upon such projects exceeds the ordinary maximum pro rata, the State must expend upon some other project or projects on the Federal-aid system, within the same year and under the direction of the Secretary of Agriculture, the amount it would otherwise have been required to expend upon the project or projects to which additional aid is granted under the provisions of the amendment.

This amendment has been in effect throughout the fiscal year 1929. No State highway department has yet requested an increase in the share of the Federal Government payable on any project.

Section 3 of the amendment approved May 21, 1928, provides that the system of Federal-aid highways on which Federal funds may be expended in any State may exceed 7 per cent of the total highway mileage of the State by the amount of the mileage on the system within national forest, Indian, or other Federal reservations in the State.

Following the passage of this amendment the several State highway departments were called upon to submit a statement of the mileage on the system within Federal reservations. These statements have been received from all but two States—Tennessee and Georgia—affected by the amendment, and all that have been received have been approved by the Secretary of Agriculture with the exception of six which are noted in Table 14. The mileages reported for the other 24 States and Hawaii listed in the latter table are those agreed upon and represent the amount by which the 7 per cent mileage may be exceeded in accordance with the amendment.

TABLE 14.—*Mileage on Federal-aid highway system within Federal reservations, being the amounts by which the 7 per cent mileage may be exceeded in each State or Territory*

State	Mileage of Federal-aid system within Federal reservations	State	Mileage of Federal-aid system within Federal reservations	State	Mileage of Federal-aid system within Federal reservations	State	Mileage of Federal-aid system within Federal reservations
Ariz	219.70	Ky	6.00	N. Mex	348.58	Utah	68.90
Ark	119.70	Me.[1]	4.50	N. Y.[1]	16.47	Va	30.72
Calif	457.00	Mich	26.50	N. C	159.34	Wash	349.69
Colo	363.50	Minn	74.80	N. Dak	23.39	W. Va	29.06
Idaho	368.90	Mont	800.82	Okla	16.25	Wis	45.50
Iowa [1]	2.00	Nebr.[1]	11.25	Oreg	360.10	Wyo	271.90
Ill	4.50	Nev	26.25	Pa	79.46	T. H.	4.35
Kans	14.70	N. H.[1]	33.42	S. Dak	450.50		

[1] Approval of reported mileage by Secretary of Agriculture pending. All other mileages reported have been approved.

The Federal highway act provided that before any project submitted in accordance therewith should be approved by the Secretary of Agriculture for any State, the State should make provision for State funds under the direct control of the State highway department in the amount required each year of the State for construction, reconstruction, and maintenance of Federal-aid highways within the State. At the time the act was passed there were certain States, the existing constitution or laws of which would not permit the State to provide revenues for highway purposes as required; and in recognition of this condition the Federal law authorized the Secretary of Agriculture to continue to approve projects for such States until three years after the passage of the act, which was approved November 9, 1921.

By subsequent amendments the full effectiveness of the requirement of the original act was three times deferred, the last amendment permitting approval of projects submitted under the appropriations authorized for the fiscal year 1929. The act of May 26, 1928, authorizing appropriations for the fiscal years 1930 and 1931 did not further extend the authority of the Secretary to waive the requirement of the original act. Consequently, all States will be expected to comply with the requirement on all projects involving the use of funds authorized to be appropriated for the fiscal year 1930 and subsequent fiscal years.

TREE PLANTING ON FEDERAL-AID HIGHWAYS

The passage of the first year since the amendment of the law authorizing Federal participation in the cost of planting shade trees along routes of the Federal-aid system has brought no proposal to that end from any State highway department. A number of States had already developed plans and begun such work along effective lines prior to the adoption of the Federal law, and their experiences indicates that the results are well worth the moderate expenditure entailed.

Through its monthly publication, Public Roads, which is circulated widely among State highway officials the bureau has published reports of the methods employed and results obtained in the splendid work of this character as carried on by the Massachusetts Department of Public Works, and informative articles with regard to the practice of other State departments will be published from time to time.

Inquiries received during the year from State highway departments, civic associations, and individuals indicate that there is considerable interest in the possible utilization of Federal aid for such plantings as a means of improving the appearance of the roadsides and enhancing the pleasure and comfort of travelers. Doubtless, there is at present in many States more pressing need to devote all available funds to other more utilitarian purposes; and States that now find it feasible to develop and carry out a systematic program of roadside beautification may prefer in some instances to use other than Federal funds for the purpose.

The department should not encourage expenditure for this purpose when to do so would mean the deferment of other more necessary improvements, and need not urge the employment of Federal aid if the States prefer to depend upon their own revenues; but the planting of suitable trees and shrubbery along all sections of the Federal-aid system where such growth can be maintained should be regarded as a necessary eventual step in the improvement of the system.

In this one respect the roads of the United States are as yet inferior to the highways of Europe. We have had too little regard for their appearance. Their greatest use is by those seeking pleasure and recreation by travel. To many such users a pleasant roadside prospect means as much as a smooth surface and easy grades. The satisfaction of this instinctive desire for beauty is an object that should no longer be ignored in our public works, and especially in the improvement of our highways. The department should lend its encouragement and offer its aid in every possible way toward this desirable end.

FEDERAL FUNDS APPORTIONED AND OBLIGATED

For the fiscal year 1929 the Federal-aid appropriation authorized was again $75,000,000. This sum, less 2½ per cent deducted for Federal administration and highway research, was apportioned among the several States and the Territory of Hawaii on December 1, 1927. The total amount apportioned was $73,125,000, and the amounts credited to each State are shown in Table 28.

As pointed out in the last annual report, the appropriations authorized for several years past in the amount of $75,000,000 have been exceeded each year by the obligations undertaken. This was possible in the beginning by reason of a large unobligated balance carried over from the earlier years, when obligations lagged behind the rate of appropriation. By June 30, 1927, these funds unobligated during the fiscal year for which they were authorized had been finally absorbed, and the fiscal year 1928 opened with an unobligated balance nearly $3.000,000 less than the apportionment for the year.

This balance was rapidly absorbed by new projects, and when the authorization for the fiscal year 1929 was apportioned the State highway departments, taking advantage of the pro-

vision of the law which permits the allotment of the apportioned funds prior to the beginning of the fiscal year for which they are apportioned, submitted projects to be paid for with the newly apportioned funds as soon as they became available. As a consequence, the unobligated balance of all apportioned funds, including the apportionment for the fiscal year 1929, was only $53,643,770.45. In other words, there had already been obligated, before the beginning of the fiscal year 1929, nearly $20,000,000 of the $73,125,000 authorized for the year.

The purpose of the provision of the law which permits the allotment of authorized funds approximately six months before the date when they become expendable was to enable the State highway departments to complete all necessary preliminary work such as the preparation of detailed plans, advertising for bids, and the execution of contracts, and be ready to begin actual construction on the new year's program promptly at the beginning of the year. No payment of the funds obligated may be made before the beginning of the fiscal year, however; and it is not intended that the provision of the law shall be used to carry on a construction program of greater magnitude than the annual authorizations will provide for. The purpose is to provide for the maintenance of a continuous program uninterrupted at the beginning of each fiscal year by the necessity of letting contracts, etc., after the money is actually available.

When a sufficient amount of work has been arranged for prior to the beginning of the fiscal year to permit of continuous operation nothing is to be gained by further anticipation of the newly available authorization.

This point has now been reached and, as shown by Table 15, the funds obligated during the fiscal year, for the first time since 1923, are within the sum apportioned. The year's expenditure, $82,097,380.38, as shown by Table 28, is still in excess of the rate of authorization, and it may be expected that this condition will exist for a year or two longer since there is a normal interval of from one to two years between obligation and expenditure of the money. But the point has now definitely been reached at which, unless there is immediate increase in the appropriations authorized, the rate of construction of Federal-aid roads, maintained for several years past, will be curtailed.

COST OF THE ROADS

The total cost of the 7,402.3 miles of initial construction and the 1,987.7 miles of stage construction completed during the year was $195,298,168.25, of which the Federal Government paid $82,736,878.92, or 42 per cent, and the States the balance. These expenditures were made over the period required to construct the roads brought to completion during the year, which was approximately two years. During the same period additional expenditures were made upon other projects under construction.

The actual disbursement of Federal funds during the year was $82,097,380.38, as shown in Table 28. This was slightly over a million dollars more than the expenditures of the previous year.

TABLE 15.—*Federal-aid funds apportioned to the States and obligated by them for the fiscal years 1923 to 1929, inclusive*

Fiscal year	Apportioned amount of appropriation authorized for the year	Amount of Federal-aid funds obligated during the year
1923	$48, 750, 000	$77, 461, 559
1924	63, 375, 000	89, 866, 864
1925	73, 125, 000	87, 294, 396
1926	73, 125, 000	79, 608, 897
1927	73, 125, 000	77, 453. 046
1928	73, 125, 000	88, 922, 185
1929	73, 125, 000	70, 428, 896
Total	477, 750, 000	571, 035, 843
Average	68, 250, 000	81, 576, 549

The largest disbursements during the year were made to California, Illinois, Michigan, New York, Ohio, Pennsylvania, and Texas. To each of these States the Federal Government paid during the year more than $3.000,000. All other States received less than that amount.

SUMMARY OF FEDERAL-AID ROAD WORK, BY STATES

The progress made in each of the States during the year and the results of the 13 years of Federal-aid road construction are set forth in the fol-

lowing condensed summary for each State.

ALABAMA

The Federal-aid highway system includes 3,884 miles. After deduction of 5.5 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,960.7, of which 183.5 miles were added during the year. At the close of the year 245.7 miles were under construction and 6.4 miles were approved for construction.

The mileage improved with Federal aid consists of 143 miles of graded and drained earth roads, 534.1 miles of sand-clay, 912.5 miles of gravel, 11.6 miles of water-bound macadam, 74.1 miles of bituminous macadam, 87.6 miles of bituminous concrete and 189.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 7.9 miles.

The total cost of all Federal-aid roads completed during the year, including 68.2 miles of stage construction, was $4,293,128.01, of which the Federal share was $2,072,634.60. The disbursement of Federal funds to the State was $1,627,208.67. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,243,381.25.

ARIZONA

The Federal-aid highway system includes 1,498 miles. A total of 887.9 miles has been improved with Federal aid, of which 66.1 miles were added during the year. At the close of the year 130.6 miles were under construction.

The mileage improved with Federal aid consists of 181 miles of graded and drained earth roads, 101.1 miles of sand-clay, 426.4 miles of gravel, 14.2 miles of water-bound macadam, 13.6 miles of bituminous macadam, 38.1 miles of bituminous concrete, and 109.4 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 24 miles of stage construction, was $1,364,000.35, of which the Federal share was $892,597.99. The disbursement of Federal funds to the State was $1,309,267.51. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,653,890.02.

ARKANSAS

The Federal-aid highway system includes 5,019.4 miles. After deduction of 35.2 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,745.1, of which 108.7 miles were added during the year. At the close of the year 109.4 miles were under construction and 25.3 miles were approved for construction.

The mileage improved with Federal aid consists of 64.5 miles of graded and drained earth roads, 3 miles of sand-clay, 1,118.5 miles of gravel, 48.3 miles of water-bound macadam, 109.1 miles of bituminous macadam, 256.3 miles of bituminous concrete, and 139 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 6.4 miles.

The total cost of all Federal-aid roads completed during the year was $2,741,801.31, of which the Federal share was $1,325,478.27. The disbursement of Federal funds to the State was $1,377,002.44. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,104,522.21.

CALIFORNIA

The Federal-aid highway system includes 4,781 miles. A total of 1,625.6 miles has been improved with Federal aid, of which 171.7 miles were added during the year. At the close of the year 275.3 miles were under construction and 31.6 miles were approved for construction.

The mileage improved with Federal aid consists of 337.7 miles of graded and drained earth roads, 398.4 miles of gravel, 24.1 miles of water-bound macadam, 95.6 miles of bituminous macadam, 165.1 miles of bituminous concrete, and 596.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 7.8 miles.

The total cost of all Federal-aid roads completed during the year, including 9.3 miles of stage construction, was $6,650,687.38, of which the Federal share was $3,228,015.10. The dis-

bursement of Federal funds to the State was $3,433,055.14. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $821,207.18.

COLORADO

The Federal-aid highway system includes 3,332 miles. A total of 1,137.4 miles has been improved with Federal aid, of which 175.1 miles were added during the year. At the close of the year 155.4 miles were under construction and 25.8 miles were approved for construction.

The mileage improved with Federal aid consists of 232.4 miles of graded and drained earth roads, 96.2 miles of sand-clay, 480.8 miles of gravel, 5.3 miles of water-bound macadam, 13 miles of bituminous concrete, and 298.8 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 10.9 miles.

The total cost of all Federal-aid roads completed during the year, including 14.8 miles of stage construction, was $5,105,451.40, of which the Federal share was $2,593,610.46. The disbursement of Federal funds to the State was $1,803,610.66. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,673,794.83.

CONNECTICUT

The Federal-aid highway system includes 835.4 miles. A total of 229.3 miles has been improved with Federal aid, of which 22.8 miles were added during the year. At the close of the year 12.5 miles were under construction and 8 miles were approved for construction.

The mileage improved with Federal aid consists of 0.2 mile of gravel, 17.4 miles of water-bound macadam, 28.7 miles of bituminous macadam, 0.6 mile of bituminous concrete, and 178.5 miles of Portland cement concrete, in addition to which there are bridges with a total length of 3.9 miles.

The total cost of all Federal-aid roads completed during the year, including 0.1 mile of stage construction, was $2,181,298.64, of which the Federal share was $606,132.05. The disbursement of Federal funds to the State was $1,059,461.12. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $558,722.80.

DELAWARE

The Federal-aid highway system includes 485.9 miles. A total of 212.9 miles has been improved with Federal aid, of which 13.4 miles were added during the year. At the close of the year 15.7 miles were under construction and 30.8 miles were approved for construction.

The mileage improved with Federal aid consists of 4.9 miles of water-bound macadam, 7 miles of bituminous macadam, 13.7 miles of bituminous concrete, 180.6 miles of Portland cement concrete, and 6.2 miles of brick, in addition to which there are bridges and their approaches with a total length of 0.5 mile.

The total cost of all Federal-aid roads completed during the year, including 3.9 miles of stage construction, was $678,062.40, of which the Federal share was $198,900.72. The disbursement of Federal funds to the State was $142,185.23. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $47,336.16.

FLORIDA

The Federal-aid highway system includes 1,926 miles. A total of 449 miles has been improved with Federal aid, of which 63.6 miles were added during the year. At the close of the year 96.6 miles were under construction.

The mileage improved with Federal aid consists of 9.2 miles of graded and drained earth roads, 15.5 miles of sand-clay, 131.1 miles of water-bound macadam, 78.9 miles of bituminous macadam, 53.6 miles of bituminous concrete, 143.2 miles of Portland cement concrete, and 10.1 miles of brick, in addition to which there are bridges and their approaches with a total length of 7.4 miles.

The total cost of all Federal-aid roads completed during the year was $2,643,407.24, of which the Federal share was $1,125,163.19. The disbursement of Federal funds to the State was $894,258.16. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,965,926.62.

GEORGIA

The Federal-aid highway system includes 5,576.7 miles. A total of 2,564.6 miles has been improved with

Federal aid, of which 113.6 miles were added during the year. At the close of the year 200.8 miles were under construction and 2.9 miles were approved for construction.

The mileage improved with Federal aid consists of 217.4 miles of graded and drained earth roads, 1,178.1 miles of sand-clay, 390.7 miles of gravel, 144.2 miles of water-bound macadam, 151.8 miles of bituminous macadam, 43.1 miles of bituminous concrete, 411.5 miles of Portland cement concrete, and 0.5 mile of brick, in addition to which there are bridges and their approaches with a total length of 27.3 miles.

The total cost of all Federal-aid roads completed during the year, including 45.2 miles of stage construction, was $2,956,121.78, of which the Federal share was $1,332,729.37. The disbursement of Federal funds to the State was $1,446,496.98. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,018,492.49.

IDAHO

The Federal-aid highway system includes 2,770 miles. A total of 1,144.5 miles has been improved with Federal aid, of which 150.8 miles were added during the year. At the close of the year 77.5 miles were under construction and 16.3 miles were approved for construction.

The mileage improved with Federal aid consists of 201.6 miles of graded and drained earth roads, 6 miles of sand-clay, 760.7 miles of gravel, 22.5 miles of water-bound macadam, 20.7 miles of bituminous macadam, 85 miles of bituminous concrete, and 44.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.4 miles.

The total cost of all Federal-aid roads completed during the year, including 66.5 miles of stage construction, was $2,435,074.59, of which the Federal share was $1,441,742.26. The disbursement of Federal funds to the State was $1,270,906.07. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $856,815.71.

ILLINOIS

The Federal-aid highway system includes 6,618.5 miles. A total of 1,888.6 miles has been improved with Federal aid, of which 203.2 miles were added during the year. At the close of the year 572.8 miles were under construction and 22.5 miles were approved for construction.

The mileage improved with Federal aid consists of 153.7 miles of graded and drained earth roads, 0.4 mile of gravel, 3.3 miles of bituminous macadam, 8.1 miles of bituminous concrete, 1,695 miles of Portland cement concrete, and 25.8 miles of brick, in addition to which there are bridges and their approaches with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year was $6,121,046.35, of which the Federal share was $2,794,215.01. The disbursement of Federal funds to the State was $5,682,636.43. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,642,000.

INDIANA

The Federal-aid highway system includes 4,701.5 miles. A total of 1,266.7 miles has been improved with Federal aid, of which 203.1 miles were added during the year. At the close of the year 275.9 miles were under construction and 35.3 miles were approved for construction.

The mileage improved with Federal aid consists of 16.5 miles of graded and drained earth roads, 42.2 miles of gravel, 41.6 miles of water-bound macadam, 23.4 miles of bituminous macadam, 12 miles of bituminous concrete, 1,120.3 miles of Portland cement concrete, and 6.6 miles of brick, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 3.5 miles of stage construction, was $6,412,238.71, of which the Federal share was $2,988,535.95. The disbursement of Federal funds to the State was $2,374,265.04. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $134,519.81.

IOWA

The Federal-aid highway system includes 7,212 miles. A total of 3,009.1 miles has been improved with Federal aid, of which 123.1 miles were added during the year. At the close of the year 135.7 miles were under construction and 25.7 miles were approved for construction.

The mileage improved with Federal aid consists of 1,329 miles of graded and drained earth roads, 616.6 miles of gravel, 1,039.6 miles of Portland cement concrete, and 21.9 miles of brick, in addition to which there are bridges and their approaches with a total length of 2 miles.

The total cost of all Federal-aid roads completed during the year, including 170.5 miles of stage construction, was $7,457,609.97, of which the Federal share was $3,382,766.29. The disbursement of Federal funds to the State was $2,704,154.16. All apportionments to the State up to June 30, 1929, had been fully obligated.

KANSAS

The Federal-aid highway system includes 7,917 miles. After deduction of 1.5 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 2,539.4, of which 338.6 miles were added during the year. At the close of the year 243.8 miles were under construction and 135.9 miles were approved for construction.

The mileage improved with Federal aid consists of 1,033.6 miles of graded and drained earth roads, 280.5 miles of sand-clay, 236.2 miles of gravel, 4.5 miles of water-bound macadam, 125.5 miles of bituminous macadam, 3.4 miles of bituminous concrete, 678.8 miles of Portland cement concrete, and 163.3 miles of brick, in addition to which there are bridges and their approaches with a total length of 13.6 miles.

The total cost of all Federal-aid roads completed during the year, including 22.9 miles of stage construction, was $5,335,022.24, of which the Federal share was $2,378,160.82. The disbursement of Federal funds to the State was $2,005,221.08. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,144,315.96.

KENTUCKY

The Federal-aid highway system includes 3,710 miles. A total of 1,314.5 miles has been improved with Federal aid, of which 169.0 miles were added during the year. At the close of the year 247.2 miles were under construction and 40.3 miles were approved for construction.

The mileage improved with Federal aid consists of 625.3 miles of graded and drained earth roads, 253.8 miles of gravel, 41.3 miles of water-bound macadam, 201.9 miles of bituminous macadam, 14.6 miles of bituminous concrete, 170.4 miles of Portland cement concrete, and 3.9 miles of brick, in addition to which there are bridges and their approaches with a total length of 3.3 miles.

The total cost of all Federal-aid roads completed during the year was $3,749,994.06, of which the Federal share was $1,830,900.22. The disbursement of Federal funds to the State was $1,504,667.75. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $757,788.11.

LOUISIANA

The Federal-aid highway system includes 2,712.9 miles. After deduction of 1.1 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,321.4, of which 46.5 miles were added during the year. At the close of the year 151.9 miles were under construction and 0.2 mile was approved for construction.

The mileage improved with Federal aid consists of 30.6 miles of graded and drained earth roads, 1,194 miles of gravel, 3.2 miles of water-bound macadam, 9.5 miles of bituminous macadam, 33.5 miles of bituminous concrete and 39.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 10.7 miles.

The total cost of all Federal-aid roads completed during the year was $1,240,120.23, of which the Federal share was $611,432.56. The disbursement of Federal funds to the State was $886,011.42. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,150,105.07.

MAINE

The Federal-aid highway system includes 1,443.6 miles. A total of 480.5 miles has been improved with Federal aid, of which 51.8 miles were added during the year. At the close of the year 44.3 miles were under construction and 29.7 miles were approved for construction.

The mileage improved with Federal aid consists of 214.8 miles of gravel, 8.6 miles of water-bound macadam, 167.6 miles of bituminous macadam, and 88.9 miles of Portland cement concrete, in addition to which there are

bridges and their approaches with a total length of 0.6 mile.

The total cost of all Federal-aid roads completed during the year was $1,583,052.78, of which the Federal share was $649,921.57. The disbursement of Federal funds to the State was $229,792.30. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,111,122.42.

MARYLAND

The Federal-aid highway system includes 1,557.1 miles. A total of 627.9 miles has been improved with Federal aid, of which 70.5 miles were added during the year. At the close of the year 3.6 miles were under construction and 39.3 miles were approved for construction.

The mileage improved with Federal aid consists of 4.7 miles of graded and drained earth roads, 31.5 miles of gravel, 1.2 miles of water-bound macadam, 235.7 miles of bituminous macadam, 22.1 miles of bituminous concrete, and 332.7 miles of Portland cement concrete.

The total cost of all Federal-aid roads completed during the year, including 10.8 miles of stage construction, was $1,847,190.79 of which the Federal share was $815,265.86. The disbursement of Federal funds to the State was $712,060.20. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $213,725.37.

MASSACHUSETTS

The Federal-aid highway system includes 1,308 miles. After deduction of 0.1 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 570.7, of which 69.7 miles were added during the year. At the close of the year 91.1 miles were under construction and 1.9 miles were approved for construction.

The mileage improved with Federal aid consists of 0.5 mile of gravel, 6.6 miles of water-bound macadam, 308.6 miles of bituminous macadam, 59.5 miles of bituminous concrete and 191.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4 miles.

The total cost of all Federal-aid roads completed during the year, including 0.2 mile of stage construction, was $3,087,998.38, of which the Federal share was $1,064,911.57. The disbursement of Federal funds to the State was $825,636.10. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,787,319.03.

MICHIGAN

The Federal-aid highway system includes 5,243 miles. After deduction of 20.9 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,470.2, of which 153.8 miles were added during the year. At the close of the year 251.3 miles were under construction and 51.6 miles were approved for construction.

The mileage improved with Federal aid consists of 10.5 miles of graded and drained earth roads, 358.3 miles of gravel, 16.3 miles of water-bound macadam, 10.4 miles of bituminous macadam, 69.5 miles of bituminous concrete, 1,002.8 miles of Portland cement concrete, and 0.4 mile of brick, in addition to which there are bridges and their approaches with a total length of 2 miles.

The total cost of all Federal-aid roads completed during the year, including 0.3 mile of stage construction, was $5,940,513.07, of which the Federal share was $2,405,266.86. The disbursement of Federal funds to the State was $3,090,670.12. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,424,179.67.

MINNESOTA

The Federal-aid highway system includes 6,884.5 miles. After deduction of 178.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 3,872.6, of which 257 miles were added during the year. At the close of the year 291 miles were under construction and 74.7 miles were approved for construction.

The mileage improved with Federal aid consists of 852.2 miles of graded and drained earth roads, 6.2 miles of sand-clay, 2,261.5 miles of gravel, 32.7 miles of bituminous concrete and 718.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 1.4 miles.

The total cost of all Federal-aid roads completed during the year, including 117.9 miles of stage construc-

tion, was $8,303,728.19, of which the Federal share was $2,879,041.58. The disbursement of Federal funds to the State was $2,216,048.53. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $410,000.

MISSISSIPPI

The Federal-aid highway system includes 3,632.1 miles. A total of 1,656.5 miles has been improved with Federal aid, of which 109.5 miles were added during the year. At the close of the year 213.8 miles were under construction and 12.9 miles were approved for construction.

The mileage improved with Federal aid consists of 233.5 miles of graded and drained earth roads, 16.7 miles of sand-clay, 1,158.3 miles of gravel, 11.1 miles of water-bound macadam, 1.5 miles of bituminous macadam, 10.4 miles of bituminous concrete, 208 miles of Portland cement concrete, and 9.7 miles of brick, in addition to which there are bridges and their approaches, with a total length of 7.3 miles.

The total cost of all Federal-aid roads completed during the year, including 30.9 miles of stage construction, was $1,750,251.06, of which the Federal share was $866,977.76. The disbursement of Federal funds to the State was $1,306,196.99. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,361,970.25.

MISSOURI

The Federal-aid highway system includes 7,530 miles. A total of 2,278.1 miles has been improved with Federal aid, of which 99.6 miles were added during the year. At the close of the year 268 miles were under construction and 16.5 miles were approved for construction.

The mileage improved with Federal aid consists of 387.5 miles of graded and drained earth roads, 2.6 miles of sand-clay, 796.6 miles of gravel, 3 miles of water-bound macadam, 44.8 miles of bituminous macadam, 17.7 miles of bituminous concrete, 994.9 miles of Portland-cement concrete, and 20.9 miles of brick, in addition to which there are bridges and their approaches, with a total length of 10.1 miles.

The total cost of all Federal-aid roads completed during the year, including 64.2 miles of stage construction, was $3,922,393.41, of which the Federal share was $1,545,883.79. The disbursement of Federal funds to the State was $2,422,487.79. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $136,556.02.

MONTANA

The Federal-aid highway system includes 4,690.5 miles. After deduction of 0.2 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,538.9, of which 244.2 miles were added during the year. At the close of the year 362.3 miles were under construction and 166 miles were approved for construction.

The mileage improved with Federal aid consists of 224.1 miles of graded and drained earth roads, 5.6 miles of sand-clay, 1,240.1 miles of gravel, 15.9 miles of water-bound macadam, 6.8 miles of bituminous macadam, 5.6 miles of bituminous concrete, and 36 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.8 miles.

The total cost of all Federal-aid roads completed during the year, including 13.4 miles of stage construction, was $2,836,700.85, of which the Federal share was $1,834,170.77. The disbursement of Federal funds to the State was $1,923,168.90. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $3,613,761.84.

NEBRASKA

The Federal-aid highway system includes 5,468.3 miles. After deduction of 0.2 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 3,628.1, of which 460.2 miles were added during the year. At the close of the year 300.7 miles were under construction and 54 miles were approved for construction.

The mileage improved with Federal aid consists of 566.1 miles of graded and drained earth roads, 2,129.1 miles of sand-clay, 812.3 miles of gravel, 1.5 miles of bituminous macadam, 14.2 miles of bituminous concrete, 77 miles of Portland cement concrete, and 19.6 miles of brick, in addition to which there are bridges and their approaches with a total length of 8.2 miles.

The total cost of all Federal-aid roads completed during the year, in-

cluding 182.5 miles of stage construction, was $4,434,167.82, of which the Federal share was $2,140,403.77. The disbursement of Federal funds to the State was $1,225,896.80. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $2,539,681.66.

NEVADA

The Federal-aid highway system includes 1,541 miles. After deduction of less than 0.1 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,081.6, of which 147 miles were added during the year. At the close of the year 226.9 miles were under construction and 0.6 mile was approved for construction.

The mileage improved with Federal aid consists of 51.2 miles of graded and drained earth roads, 9.7 miles of sand-clay, 833.4 miles of gravel, 14.9 miles of water-bound macadam, 122.5 miles of bituminous macadam, 2 miles of bituminous concrete, and 45.2 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 2.7 miles.

The total cost of all Federal-aid roads completed during the year, including 60.8 miles of stage construction, was $1,313,310.42, of which the Federal share was $1,120,157.11. The disbursement of Federal funds to the State was $863,467.12. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $204,689.18.

NEW HAMPSHIRE

The Federal-aid highway system includes 980.9 miles. A total of 332.7 miles has been improved with Federal aid, of which 28.1 miles were added during the year. At the close of the year 13.5 miles were under construction and 6.5 miles were approved for construction.

The mileage improved with Federal aid consists of 99.2 miles of gravel, 70 miles of water-bound macadam, 92.4 miles of bituminous macadam, 32.4 miles of bituminous concrete, and 34.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year was $1,001,020.85, of which the Federal share was $409,954.34. The disbursement of Federal funds to the State was $365,278.82. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $188,-125.54.

NEW JERSEY

The Federal-aid highway system includes 1,181.7 miles. A total of 462.6 miles has been improved with Federal aid, of which 44.4 miles were added during the year. At the close of the year 54.3 miles were under construction and 8.7 miles were approved for construction.

The mileage improved with Federal aid consists of 8.9 miles of graded and drained earth roads, 5.6 miles of gravel, 22.3 miles of bituminous concrete, and 423.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year was $2,847,737.45, of which the Federal share was $659,548.27. The disbursement of Federal funds to the State was $768,902.44. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $625,470.08.

NEW MEXICO

The Federal-aid highway system includes 3,367.7 miles. After deduction of 9.9 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,868.1, of which 137.6 miles were added during the year. At the close of the year 137.6 miles were under construction and 9 miles were approved for construction.

The mileage improved with Federal aid consists of 273.1 miles of graded and drained earth roads, 5.1 miles of sand-clay, 1,503.2 miles of gravel, 0.7 mile of bituminous concrete, and 81.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.1 miles.

The total cost of all Federal-aid roads completed during the year, including 5.6 miles of stage construction, was $2,229,501.77, of which the Federal share was $1,467,188.58. The disbursement of Federal funds to the State was $2,106,513.24. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,153,455.48.

NEW YORK

The Federal-aid highway system includes 5,451 miles. After deduction of 1.1 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 2,182.7, of which 318.9 miles were added during the year. At the close of the year 343.6 miles were under construction and 137.5 miles were approved for construction.

The mileage improved with Federal aid consists of 21.6 miles of graded and drained earth roads, 4.6 miles of sand-clay, 58.4 miles of gravel, and 361.7 miles of bituminous macadam, 12.6 miles of bituminous concrete, 1,721.2 miles of Portland cement concrete, and 0.7 mile of brick, in addition to which there are bridges and their approaches with a total length of 1.9 miles.

The total cost of all Federal-aid roads completed during the year, including 8.5 miles of stage construction, was $17,998,988.48, of which the Federal share was $5,030,321.47. The disbursement of Federal funds to the State was $3,761,689.93. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $4,295,740.58.

NORTH CAROLINA

The Federal-aid highway system includes 3,944.4 miles. A total of 1,711.9 miles has been improved with Federal aid, of which 125.6 miles were added during the year. At the close of the year 87.6 miles were under construction and 14.2 miles were approved for construction.

The mileage improved with Federal aid consists of 103.8 miles of graded and drained earth roads, 459.7 miles of sand-clay, 63.6 miles of gravel, 19.6 miles of water-bound macadam, 37.9 miles of bituminous macadam, 249.5 miles of bituminous concrete, and 774.6 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.2 miles.

The total cost of all Federal-aid roads completed during the year, including 25.6 miles of stage construction, was $3,347,608.32, of which the Federal share was $1,558,571.88. The disbursement of Federal funds to the State was $1,716,874.85. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,721,786.21.

NORTH DAKOTA

The Federal-aid highway system includes 7,396.6 miles. After deduction of 7.1 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 3,676.5, of which 500.6 miles were added during the year. At the close of the year 620.7 miles were under construction and 124.7 miles were approved for construction.

The mileage improved with Federal aid consists of 1,344.1 miles of graded and drained earth roads, 2,313.4 miles of gravel, 5.4 miles of water-bound macadam, 1.9 miles of bituminous concrete, and 4.7 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 7 miles.

The total cost of all Federal-aid roads completed during the year, including 331.3 miles of stage construction was $2,965,387.55, of which the Federal share was $1,358,653.48. The disbursement of Federal funds to the State was $1,325,962.17. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $982,621.03.

OHIO

The Federal-aid highway system includes 5,899.3 miles. A total of 2,013.1 miles has been improved with Federal aid, of which 201.2 miles were added during the year. At the close of the year 257.2 miles were under construction and 59.7 miles were approved for construction.

The mileage improved with Federal aid consists of 104 miles of graded and drained earth roads, 7.9 miles of gravel, 143.1 miles of water-bound macadam, 400.5 miles of bituminous macadam, 97.3 miles of bituminous concrete, 757 miles of Portland cement concrete, and 500.1 miles of brick, in addition to which there are bridges and their approaches with a total length of 3.2 miles.

The total cost of all Federal-aid roads completed during the year, including 12.1 miles of stage construction, was $7,216,174.12, of which the Federal share was $2,876,713.72. The disbursement of Federal funds to the State was $3,937,359.91. The unobligated balance available on June 30, 1929, of all appropriations authorized

and apportioned up to that date was $2,755,365.68.

OKLAHOMA

The Federal-aid highway system includes 5,594.3 miles. A total of 1,823.7 miles has been improved with Federal aid, of which 233.3 miles were added during the year. At the close of the year 84.6 miles were under construction and 38.4 miles were approved for construction.

The mileage improved with Federal aid consists of 416.1 miles of graded and drained earth roads, 2.3 miles of sand-clay, 605.6 miles of gravel, 6.3 miles of water-bound macadam, 49.5 miles of bituminous macadam, 102.2 miles of bituminous concrete, 620.5 miles of Portland cement concrete, and 8.9 miles of brick, in addition to which there are bridges and their approaches with a total length of 12.3 miles.

The total cost of all Federal-aid roads completed during the year, including 44 miles of stage construction, was $5,303,528.87 of which the Federal share was $2,391,756.26. The disbursement of Federal funds to the State was $1,614,336.80. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $913,425.83.

OREGON

The Federal-aid highway system includes 3,239.7 miles. A total of 1,147.9 miles has been improved with Federal aid, of which 43 miles were added during the year. At the close of the year 48.2 miles were under construction and 72.9 miles were approved for construction.

The mileage improved with Federal aid consists of 155 miles of graded and drained earth roads, 799.1 miles of gravel, 25.6 miles of water-bound macadam, 11.5 miles of bituminous macadam, 52.9 miles of bituminous concrete, and 99.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.9 miles.

The total cost of all Federal-aid roads completed during the year was $1,776,270.44, of which the Federal share was $922,764.06. The disbursement of Federal funds to the State was $544,205.11. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,430,698.62.

PENNSYLVANIA

The Federal-aid highway system includes 5,058.2 miles. A total of 2,072.9 miles has been improved with Federal aid, of which 250 miles were added during the year. At the close of the year 216.6 miles were under construction and 81.9 miles were approved for construction.

The mileage improved with Federal aid consists of 137.9 miles of graded and drained earth roads, 18.4 miles of bituminous macadam, 101.1 miles of bituminous concrete, 1,786.9 miles of Portland cement concrete, and 26.4 miles of brick, in addition to which there are bridges with a total length of 2.2 miles.

The total cost of all Federal-aid roads completed during the year was $12,453,120.64, of which the Federal share was $3,958,562.36. The disbursement of Federal funds to the State was $3,801,073.14. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,855,478.52.

RHODE ISLAND

The Federal-aid highway system includes 362.4 miles. A total of 165.2 miles has been improved with Federal aid, of which 29 miles were added during the year. At the close of the year 23.9 miles were under construction and 1.5 miles were approved for construction.

The mileage improved with Federal aid consists of 1.8 miles of water-bound macadam, 44.2 miles of bituminous macadam, 49.7 miles of bituminous concrete, and 69.4 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 0.1 mile.

The total cost of all Federal-aid roads completed was $1,637,611.43, of which the Federal share was $479,326.40. The disbursement of Federal funds to the State was $402,771. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $548,347.68.

SOUTH CAROLINA

The Federal-aid highway system includes 3,230 miles. After deduction of less than 0.1 mile improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,813.7, of which 98.8 miles were added during the

year. At the close of the year 166.3 miles were under construction and 14.2 miles were approved for construction.

The mileage improved with Federal aid consists of 25.3 miles of graded and drained earth roads, 1,236.4 miles of sand-clay, 123 miles of gravel, 8.9 miles of water-bound macadam, 10.7 miles of bituminous macadam, 154.4 miles of bituminous concrete, 237.4 miles of Portland cement concrete, and 0.2 mile of brick, in addition to which there are bridges and their approaches with a total length of 17.4 miles.

The total cost of all Federal-aid roads completed during the year, including 90.3 miles of stage construction, was $5,493,642.34, of which the Federal share was $1,289,919.53. The disbursement of Federal funds to the State was $816,484.11. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $886,629.83.

SOUTH DAKOTA

The Federal-aid highway system includes 6,001.5 miles. A total of 3,310.8 miles has been improved with Federal aid, of which 450.7 miles were added during the year. At the close of the year 536.3 miles were under construction and 49 miles were approved for construction.

The mileage improved with Federal aid consists of 264.5 miles of graded and drained earth roads, 35 miles of sand-clay, 2,996.9 miles of gravel, 4 miles of bituminous macadam, and 7.2 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 3.2 miles.

The total cost of all Federal-aid roads completed during the year, including 125.1 miles of stage construction, was $2,526,718.82, of which the Federal share was $1,345,451.61. The disbursement of Federal funds to the State was $1,107,488.48. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $371,595.94.

TENNESSEE

The Federal-aid highway system includes 3,252.8 miles. A total of 1,148.4 miles has been improved with Federal aid, of which 72.8 miles were added during the year. At the close of the year 119.8 miles were under construction and 15.9 miles were approved for construction.

The mileage improved with Federal aid consists of 67.2 miles of graded and drained earth roads, 123.8 miles of gravel, 52.3 miles of water-bound macadam, 428.7 miles of bituminous macadam, 40.5 miles of bituminous concrete and 431.3 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.6 miles.

The total cost of all Federal-aid roads completed during the year, including 118.6 miles of stage construction, was $5,010,358.01, of which the Federal share was $2,231,811.60. The disbursement of Federal funds to the State was $2,245,874.99. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,096,306.59.

TEXAS

The Federal-aid highway system includes 11,691 miles. After deduction of 7.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 6,064.1, of which 235.3 miles were added during the year. At the close of the year 911.1 miles were under construction and 173.2 miles were approved for construction.

The mileage improved with Federal aid consists of 567.2 miles of graded and drained earth roads, 90.4 miles of sand-clay, 2,937.9 miles of gravel, 518.8 miles of water-bound macadam, 886.3 miles of bituminous macadam, 137.2 miles of bituminous concrete, 883.8 miles of Portland cement concrete, and 29.2 miles of brick, in addition to which there are bridges and their approaches with a total length of 13.3 miles.

The total cost of all Federal-aid roads completed during the year, including 197.2 miles of stage construction, was $9,233,596.56, of which the Federal share was $4,016,467.80. The disbursement of Federal funds to the State was $4,191,191.70. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $36,517.80.

UTAH

The Federal-aid highway system includes 1,686.3 miles. A total of 918.3

miles has been improved with Federal aid, of which 99.8 miles were added during the year. At the close of the year 68 miles were under construction and 18.4 miles were approved for construction.

The mileage improved with Federal aid consists of 105.3 miles of graded and drained earth roads, 40.8 miles of sand-clay, 607 miles of gravel, 23.8 miles of water-bound macadam, 29.7 miles of bituminous macadam, 9.9 miles of bituminous concrete, and 99.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches, with a total length of 2.3 miles.

The total cost of all Federal-aid roads completed during the year, including 29.8 miles of stage construction, was $1,331,229.22, of which the Federal share was $963,406.50. The disbursement of Federal funds to the State was $1,066,011.51. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $361,621.97.

VERMONT

The Federal-aid highway system includes 1,043 miles. A total of 229 miles has been improved with Federal aid, of which 27.6 miles were added during the year. At the close of the year 38.1 miles were under construction and 0.1 mile was approved for construction.

The mileage improved with Federal aid consists of 101.9 miles of gravel, 8.2 miles of water-bound macadam, 51.6 miles of bituminous macadam, and 60.8 miles of Portland cement concrete, in addition to which there are bridges and their approaches, with a total length of 6.5 miles.

The total cost of all Federal-aid roads completed during the year was $1,174,278.93, of which the Federal share was $418,215.18. The disbursement of Federal funds to the State was $406,248.51. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $62,786.68.

VIRGINIA

The Federal-aid highway system includes 3,291.5 miles. After deduction of 8.9 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,345.5, of which 84.8 miles were added during the year. At the close of the year 114.2 miles were under construction and 22.1 miles were approved for construction.

The mileage improved with Federal aid consists of 55.1 miles of graded and drained earth roads, 203.4 miles of sand-clay, 116.2 miles of gravel, 107.2 miles of water-bound macadam, 357.9 miles of bituminous macadam, 13.7 miles of bituminous concrete, and 487.7 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.3 miles.

The total cost of all Federal-aid roads completed during the year, including 6.3 miles of stage construction, was $2,501,862.94, of which the Federal share was $1,108,813.98. The disbursement of Federal funds to the State was $1,297,653.57. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $758,318.82.

WASHINGTON

The Federal-aid highway system includes 2,927.5 miles. A total of 854.4 miles has been improved with Federal aid, of which 76.7 miles were added during the year. At the close of the year 91.2 miles were under construction and 21.9 miles were approved for construction.

The mileage improved with Federal aid consists of 171 miles of graded and drained earth roads, 371.6 miles of gravel, and 307.5 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 4.3 miles.

The total cost of all Federal-aid roads completed during the year, including 5 miles of stage construction, was $2,095,070.15, of which the Federal share was $872,594.07. The disbursement of Federal funds to the State was $1,498,282.57. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $917,100.03.

WEST VIRGINIA

The Federal-aid highway system includes 2,214 miles. A total of 683.3 miles has been improved with Federal aid, of which 94.1 miles were added during the year. At the close of the year 86.7 miles were under construc-

tion and 24.8 miles were approved for construction.

The mileage improved with Federal aid consists of 272.6 miles of graded and drained earth roads, 3.9 miles of sand-clay, 25.4 miles of gravel, 4.8 miles of water-bound macadam, 170.8 miles of bituminous macadam, 22.9 miles of bituminous concrete, 170 miles of Portland cement concrete, and 11.4 miles of brick, in addition to which there are bridges and their approaches with a total length of 1.5 miles.

The total cost of all Federal-aid roads completed during the year, was $2,287,197.12, of which the Federal share was $1,071,351.56. The disbursement of Federal funds to the State was $1,090,621.80. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $77,371.86.

WISCONSIN

The Federal-aid highway system includes 5,493.4 miles. After deduction of 197.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 2,056.1, of which 211 miles were added during the year. At the close of the year 336.4 miles were under construction and 38.9 miles were approved for construction.

The mileage improved with Federal aid consists of 146.3 miles of graded and drained earth roads, 84 miles of sand-clay, 1,011.1 miles of gravel, 6.7 miles of water-bound macadam, 13.8 miles of bituminous macadam, 0.5 mile of bituminous concrete, and 791.3 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 2.4 miles.

The total cost of all Federal-aid roads completed during the year, including 35.8 miles of stage construction, was $6,057,896.17, of which the Federal share was $2,804,171.88. The disbursement of Federal funds to the State was $2,438,786.46. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $338,759.36.

WYOMING

The Federal-aid highway system includes 3,097 miles. After deduction of 10.4 miles improved prior to 1921 and not included in the system, the total mileage now classified as improved with Federal aid is 1,674.5, of which 219.6 miles were added during the year. At the close of the year 164 miles were under construction and 28.7 miles were approved for construction.

The mileage improved with Federal aid consists of 523.3 miles of graded and drained earth roads, 483.3 miles of sand-clay, 581.6 miles of gravel, 21.4 miles of water-bound macadam, 21.2 miles of bituminous macadam, 22.1 miles of bituminous concrete, and 15.9 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 5.7 miles.

The total cost of all Federal-aid roads completed during the year, including 42.6 miles of stage construction, was $2.063,080.42, of which the Federal share was $1,285,898.27. The disbursement of Federal funds to the State was $1,165,778.45. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $313,862.69.

HAWAII

The Federal-aid highway system includes 174.6 miles. A total of 39.5 miles has been improved with Federal aid, of which 3.3 miles were added during the year. At the close of the year 6.6 miles were under construction and 16.6 miles were approved for construction.

The mileage improved with Federal aid consists of 11.5 miles of bituminous macadam, 8.6 miles of bituminous concrete, and 19 miles of Portland cement concrete, in addition to which there are bridges and their approaches with a total length of 0.4 mile.

The total cost of all Federal-aid roads completed during the year was $361,916.22, of which the Federal share was $90,400.62. The disbursement of Federal funds to the Territory was $92,158.11. The unobligated balance available on June 30, 1929, of all appropriations authorized and apportioned up to that date was $1,072,664.16.

FEDERAL-AID STATISTICS

Statistical information relative to the apportionment, obligation, and disbursement of Federal aid during the fiscal year 1929; the cost of roads completed and the estimated cost of roads under construction; and the type of the roads completed and under construction, etc, is given in Tables 16 to 28, inclusive.

TABLE 16.—*Mileage of the designated Federal-aid highway system in each State and mileage improved with Federal aid to June 30, 1929*

State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1929	State	Mileage of designated Federal-aid highway system	Mileage completed with Federal-aid to June 30, 1929
Alabama	3,884.0	1,960.7	New Hampshire	980.9	332.7
Arizona	1,498.0	887.9	New Jersey	1,181.7	462.6
Arkansas	5,019.4	1,745.1	New Mexico	3,367.7	1,868.1
California	4,781.0	1,625.6	New York	5,451.0	2,182.7
Colorado	3,332.0	1,137.4	North Carolina	3,944.4	1,711.9
Connecticut	835.4	229.3	North Dakota	7,396.6	3,676.5
Delaware	485.9	212.9	Ohio	5,899.3	2,013.1
Florida	1,926.0	449.0	Oklahoma	5,594.3	1,823.7
Georgia	5,576.7	2,564.6	Oregon	3,239.7	1,147.9
Idaho	2,770.0	1,144.5	Pennsylvania	5,058.2	2,072.9
Illinois	6,618.5	1,888.6	Rhode Island	362.4	165.2
Indiana	4,701.5	1,266.7	South Carolina	3,230.0	1,813.7
Iowa	7,212.0	3,009.1	South Dakota	6,001.5	3,310.8
Kansas	7,917.0	2,539.4	Tennessee	3,252.8	1,148.4
Kentucky	3,710.0	1,314.5	Texas	11,691.0	6,064.1
Louisiana	2,712.9	1,321.4	Utah	1,686.3	918.3
Maine	1,443.6	480.5	Vermont	1,043.0	229.0
Maryland	1,557.1	627.9	Virginia	3,291.5	1,345.5
Massachusetts	1,308.0	570.7	Washington	2,927.5	854.4
Michigan	5,243.0	1,470.2	West Virginia	2,214.0	683.3
Minnesota	6,884.5	3,872.6	Wisconsin	5,493.4	2,056.1
Mississippi	3,632.1	1,656.5	Wyoming	3,097.0	1,674.5
Missouri	7,530.0	2,278.1	Hawaii	174.6	39.5
Montana	4,690.5	1,538.9			
Nebraska	5,468.3	3,628.0	Total	188,857.2	78,096.6
Nevada	1,541.0	1,081.6			

TABLE 17.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1929*

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
Alabama	$4,293,128.01	$2,072,634.60	183.5	68.2	251.7
Arizona	1,364,000.35	892,597.99	66.1	24.0	90.1
Arkansas	2,741,801.31	1,325,478.27	108.7		108.7
California	6,650,687.38	3,228,015.10	171.7	9.3	181.0
Colorado	5,105,451.40	2,593,610.46	175.1	14.8	189.9
Connecticut	2,181,298.64	606,132.05	22.8	.1	22.9
Delaware	678,062.40	198,900.72	13.4	3.9	17.3
Florida	2,643,407.24	1,125,163.19	63.6		63.6
Georgia	2,956,121.78	1,332,729.37	113.6	45.2	158.8
Idaho	2,435,074.59	1,441,742.26	150.8	66.5	217.3
Illinois	6,121,046.35	2,794,215.01	203.2		203.2
Indiana	6,412,238.71	2,988,535.95	203.1	3.5	206.6
Iowa	7,457,609.97	3,382,766.29	123.1	170.5	293.6
Kansas	5,335,022.24	2,378,160.82	338.6	22.9	361.5
Kentucky	3,749,994.06	1,830,900.22	169.0		169.0
Louisiana	1,240,120.23	611,432.56	46.5		46.5
Maine	1,583,052.78	649,921.57	51.8		51.8
Maryland	1,847,190.79	815,265.86	70.5	10.8	81.3
Massachusetts	3,087,998.38	1,064,911.57	69.7	.2	69.9
Michigan	5,940,513.07	2,405,266.86	153.8	.3	154.1
Minnesota	8,303,728.19	2,879,041.58	257.0	117.9	374.9
Mississippi	1,750,251.06	866,977.76	109.5	30.9	140.4
Missouri	3,922,393.41	1,545,883.79	99.6	64.2	163.8
Montana	2,836,700.85	1,834,170.77	244.2	13.4	257.6
Nebraska	4,434,167.82	2,140,403.77	460.2	182.5	642.7
Nevada	1,313,310.42	1,120,157.11	147.0	60.8	207.8
New Hampshire	1,001,020.85	409,954.34	28.1		28.1
New Jersey	2,847,737.45	659,548.27	44.4		44.4
New Mexico	2,229,501.77	1,467,188.58	137.6	5.6	143.2
New York	17,998,988.48	5,030,321.47	318.9	8.5	327.4
North Carolina	3,347,608.32	1,558,571.88	125.6	25.6	151.2
North Dakota	2,965,387.55	1,358,653.48	500.6	331.3	831.9
Ohio	7,216,174.12	2,876,713.72	201.2	12.1	213.3
Oklahoma	5,303,528.87	2,391,756.26	233.3	44.0	277.3
Oregon	1,776,270.44	922,764.06	43.0		43.0
Pennsylvania	12,453,120.64	3,958,562.36	250.0		250.0
Rhode Island	1,637,611.43	479,326.40	29.0		29.0
South Carolina	5,493,642.34	1,289,919.53	98.8	90.3	189.1

TABLE 17.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, completed during the fiscal year 1929*—Continued

State	Total cost	Federal aid	Mileage		
			Initial	Stage	Total
South Dakota	$2,526,718.82	$1,345,451.61	450.7	125.1	575.8
Tennessee	5,010,358.01	2,231,811.60	72.8	118.6	191.4
Texas	9,233,596.56	4,016,467.80	235.3	197.2	432.5
Utah	1,331,229.22	963,406.50	99.8	29.8	129.6
Vermont	1,174,278.93	418,215.18	27.6		27.6
Virginia	2,501,862.94	1,108,813.98	84.8	6.3	91.1
Washington	2,095,070.15	872,594.07	76.7	5.0	81.7
West Virginia	2,287,197.12	1,071,351.56	94.1		94.1
Wisconsin	5,057,896.17	2,804,171.88	211.0	35.8	246.8
Wyoming	2,063,080.42	1,285,898.27	219.6	42.6	262.2
Hawaii	361,916.22	90,400.62	3.3		3.3
Total	195,298,168.25	82,736,878.92	7,402.3	1,987.7	9,390.0

TABLE 18.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, under construction on June 30, 1929, by States*

State	Estimated total cost	Federal-aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$3,258,926.95	$1,627,437.04	224.7	21.0	245.7
Arizona	2,199,816.28	1,859,989.34	100.5	30.1	130.6
Arkansas	3,656,725.36	1,799,403.14	102.9	6.5	109.4
California	9,612,659.34	4,324,210.30	265.4	9.9	275.3
Colorado	3,993,909.55	2,068,568.40	128.8	26.6	155.4
Connecticut	792,275.72	217,937.99	12.5		12.5
Delaware	753,366.80	298,843.42	15.7		15.7
Florida	2,734,529.08	1,135,234.01	90.9	5.7	96.6
Georgia	3,757,836.66	1,673,267.89	163.9	36.9	200.8
Idaho	905,547.56	542,064.66	77.5		77.5
Illinois	19,245,292.23	8,620,190.39	572.8		572.8
Indiana	8,958,464.70	4,278,868.78	275.9		275.9
Iowa	3,527,407.02	1,582,809.17	53.4	82.3	135.7
Kansas	3,432,075.07	1,346,245.56	243.8		243.8
Kentucky	4,598,602.22	2,194,672.33	243.8	3.4	247.2
Louisiana	3,623,495.55	1,803,989.15	151.9		151.9
Maine	1,883,862.41	646,104.12	44.3		44.3
Maryland	167,810.00	62,360.00	3.6		3.6
Massachusetts	5,097,641.63	1,538,226.50	91.1		91.1
Michigan	10,224,762.17	4,374,874.40	251.3		251.3
Minnesota	4,888,903.63	1,671,618.27	197.6	93.4	291.0
Mississippi	4,736,296.26	2,130,632.99	196.4	17.4	213.8
Missouri	9,068,176.63	3,483,757.97	211.8	56.2	268.0
Montana	5,089,960.81	3,187,267.45	354.2	8.1	362.3
Nebraska	2,892,184.38	1,438,788.31	240.5	60.2	300.7
Nevada	1,144,050.62	1,002,938.37	114.5	112.4	226.9
New Hampshire	561,177.02	198,553.31	12.5	1.0	13.5
New Jersey	4,565,550.60	815,205.00	54.3		54.3
New Mexico	2,261,247.93	1,429,503.15	137.6		137.6
New York	23,451,671.43	5,137,430.55	343.6		343.6
North Carolina	1,375,152.61	687,576.28	80.4	7.2	87.6
North Dakota	3,234,518.96	1,329,006.06	482.5	138.2	620.7
Ohio	11,976,628.49	4,206,990.80	257.2		257.2
Oklahoma	1,499,899.94	668,725.70	78.8	5.8	84.6
Oregon	793,251.14	391,848.56	48.2		48.2
Pennsylvania	12,854,654.57	3,395,873.25	202.5	14.1	216.6
Rhode Island	1,562,040.98	403,211.55	23.9		23.9
South Carolina	4,080,278.30	823,426.61	128.9	37.4	166.3
South Dakota	3,727,628.20	2,010,354.66	488.6	47.7	536.3
Tennessee	3,605,466.41	1,672,582.01	119.8		119.8
Texas	17,723,807.68	7,610,655.50	657.9	253.2	911.1
Utah	1,727,297.51	1,165,860.46	68.0		68.0
Vermont	1,889,278.37	632,504.02	38.1		38.1
Virginia	2,754,082.68	1,196,688.51	95.3	18.9	114.2
Washington	3,721,579.95	1,238,875.25	73.1	18.1	91.2
West Virginia	2,842,654.78	1,149,762.08	68.9	17.8	86.7
Wisconsin	9,777,590.68	4,308,468.14	307.1	29.3	336.4
Wyoming	1,526,197.61	979,518.74	155.1	8.9	164.0
Hawaii	402,261.10	137,426.82	6.6		6.6
Total	238,158,495.57	96,500,346.96	8,358.6	1,167.7	9,526.3

TABLE 19.—*Total cost, Federal aid and mileage of Federal-aid roads, initial and stage construction, approved for construction, as of June 30, 1929, by States*

State	Estimated total cost	Federal aid allotted	Mileage		
			Initial	Stage	Total
Alabama	$430, 398. 21	$215, 199. 10	6. 4	14. 3	20. 7
Arizona	226, 598. 57	170, 606. 04		29. 4	29. 4
Arkansas	529, 229. 73	262, 782. 41	25. 3	6. 0	31. 3
California	2, 536, 332. 71	1, 117, 206. 50	31. 6	19. 5	51. 1
Colorado	770, 144. 32	412, 855. 91	25. 8	12. 4	38. 2
Connecticut	1, 372, 239. 99	559, 118. 95	8. 0		8. 0
Delaware	535, 184. 40	262, 260. 69	30. 8		30. 8
Georgia	37, 129. 17	18, 192. 86	2. 9		2. 9
Idaho	202, 122. 35	121, 880. 16	16. 3		16. 3
Illinois	,648, 000. 00	324, 000. 00	22. 5		22. 5
Indiana	1, 058, 051. 61	504, 631. 00	35. 3		35. 3
Iowa	2, 464, 679. 61	998, 305. 35	25 7	63. 9	89. 6
Kansas	2, 067, 844. 93	981, 277. 15	135. 9	11. 5	147. 4
Kentucky	463, 762. 16	231, 833. 31	40. 3		40. 3
Louisiana	287, 899. 05	105, 752. 71	. 2	8. 2	8. 4
Maine	941, 331. 71	381, 984 35	29. 7		29. 7
Maryland	980, 260. 95	456, 710. 00	39. 3	16. 8	56. 1
Massachusetts	258, 186. 27	75, 125. 87	1. 9	3. 4	5. 3
Michigan	2, 155, 000. 00	933, 716. 86	51. 6	9. 5	61. 1
Minnesota	1, 498, 509. 36	416, 297. 96	74. 7	16. 6	91. 3
Mississippi	188, 293. 15	94, 146. 56	12. 9		12. 9
Missouri	3, 342, 376. 38	1, 279, 693. 85	16. 5	91. 4	107. 9
Montana	1, 758, 524. 56	967, 070. 97	166. 0		166. 0
Nebraska	1, 558, 312. 11	711, 443. 12	54 0	134. 7	188. 7
Nevada	334, 482. 30	297, 187. 45	. 6	92. 4	93. 0
New Hampshire	252, 935 68	97, 410. 00	6. 5		6. 5
New Jersey	521, 240. 38	130, 335. 00	8. 7		8. 7
New Mexico	241, 716. 29	154, 094. 12	9. 0		9. 0
New York	9, 105, 046. 33	2, 054, 505. 00	137. 5		137. 5
North Carolina	272, 103. 36	131, 967. 67	14. 2		14. 2
North Dakota	1, 143, 646. 71	429, 101. 68	124. 7	231. 9	356. 6
Ohio	4, 310, 036. 60	997, 860. 29	59. 7	19. 3	79. 0
Oklahoma	1, 392, 362. 75	617, 562. 37	38. 4	17. 1	55. 5
Oregon	1, 137, 687. 38	708, 004. 14	72. 9	44. 8	117. 7
Pennsylvania	3, 619, 350. 36	1, 267, 978. 20	81. 9		81. 9
Rhode Island	70, 170. 40	22, 755. 00	1. 5		1. 5
South Carolina	368, 829. 54	85, 000. 00	14. 2		14. 2
South Dakota	440, 580. 75	232, 278. 85	49. 0	28. 6	77. 6
Tennessee	342, 937. 22	171, 468. 59	15. 9		15. 9
Texas	7, 000, 086. 00	2, 998, 213. 00	173. 2	139. 1	312. 3
Utah	246, 869. 73	182, 643. 58	18. 4		18. 4
Vermont	20, 051. 36	10, 025. 68	. 1		. 1
Virginia	476, 187. 94	201, 193. 99	22. 1	3. 1	25. 2
Washington	1, 039, 326. 93	480, 000. 00	21. 9	11. 7	33. 6
West Virginia	1, 323, 627. 44	515, 302. 72	24. 8	12. 3	37. 1
Wisconsin	754, 725. 77	363, 097. 16	38. 9		38. 9
Wyoming	213, 573. 07	140, 210. 67	28. 7	27. 4	56. 1
Hawaii	562, 688. 38	247, 259. 61	16. 6		16. 6
Total	61, 500, 673. 97	24, 137, 546. 45	1, 833. 0	1, 065. 3	2, 898. 3

TABLE 20.—*Mileage of Federal-aid roads improved as of June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	143.0	534.1	912.5	11.6	74.1	87.6	189.9		7.9	1,960.7
Arizona	181.0	101.1	426.4	14.2	13.6	38.1	109.4		4.1	887.9
Arkansas	64.5	3.0	1,118.5	48.3	109.1	256.3	139.0		6.4	1,745.1
California	337.7		398.4	24.1	95.6	165.1	596.9		7.8	1,625.6
Colorado	232.4	96.2	480.8	5.3		13.0	298.8		10.9	1,137.4
Connecticut			.2	17.4	28.7	.6	178.5		3.9	229.3
Delaware				4.9	7.0	13.7	180.6	6.2	.5	212.9
Florida	9.2	15.5		131.1	78.9	53.6	143.2	10.1	7.4	449.0
Georgia	217.4	1,178.1	390.7	144.2	151.8	43.1	411.5	.5	27.3	2,564.6
Idaho	201.6	6.0	760.7	22.5	20.7	85.0	44.6		3.4	1,144.5
Illinois	153.7		.4		3.3	8.1	1,695.0	25.8	2.3	1,888.6
Indiana	16.5		42.2	41.6	23.4	12.0	1,120.3	6.6	4.1	1,266.7
Iowa	1,329.0		616.6				1,039.6	21.9	2.0	3,009.1
Kansas	1,033.6	280.5	236.2	4.5	125.5	3.4	678.8	163.3	13.6	2,539.4
Kentucky	625.3		253.8	41.3	201.9	14.6	170.4	3.9	3.3	1,314.5
Louisiana	30.6		1,194.0	3.2	9.5	33.5	39.9		10.7	1,321.4
Maine			214.8	8.6	167.6		88.9		.6	480.5
Maryland	4.7		31.5	1.2	235.7	22.1	332.7			627.9
Massachusetts			.5	6.6	308.6	59.5	191.5		4.0	570.7
Michigan	10.5		358.3	16.3	10.4	69.5	1,002.8	.4	2.0	1,470.2
Minnesota	852.2	6.2	2,261.5			32.7	718.6		1.4	3,872.6
Mississippi	233.5	16.7	1,158.3	11.1	1.5	10.4	208.0	9.7	7.3	1,656.5
Missouri	387.5	2.6	796.6	3.0	44.8	17.7	994.9	20.9	10.1	2,278.1
Montana	224.1	5.6	1,240.1	15.9	6.8	5.6	36.0		4.8	1,538.9
Nebraska	566.1	2,129.1	812.3		1.5	14.2	77.0	19.6	8.2	3,628.0
Nevada	51.2	9.7	833.4	14.9	122.5	2.0	45.2		2.7	1,081.6
New Hampshire			99.2	70.0	92.4	32.4	34.6		4.1	332.7
New Jersey	8.9		5.6			22.3	423.5		2.3	462.6
New Mexico	273.1	5.1	1,503.2			.7	81.9		4.1	1,868.1
New York	21.6	4.6	58.4		361.7	12.6	1,721.2	.7	1.9	2,182.7
North Carolina	103.8	459.7	63.6	19.6	37.9	249.5	774.6		3.2	1,711.9
North Dakota	1,344.1		2,313.4	5.4		1.9	4.7		7.0	3,676.5
Ohio	104.0		7.9	143.1	400.5	97.3	757.0	500.1	3.2	2,013.1
Oklahoma	416.1	2.3	605.6	6.3	49.5	102.2	620.5	8.9	12.3	1,823.7
Oregon	155.0		799.1	25.6	11.5	52.9	99.9		3.9	1,147.9
Pennsylvania	137.9				18.4	101.1	1,786.9	26.4	2.2	2,072.9
Rhode Island				1.8	44.2	49.7	69.4		.1	165.2
South Carolina	25.3	1,236.4	123.0	8.9	10.7	154.4	237.4	.2	17.4	1,813.7
South Dakota	264.5	35.0	2,996.9		4.0		7.2		3.2	3,310.8
Tennessee	67.2		123.8	52.3	428.7	40.5	431.3		4.6	1,148.4
Texas	567.2	90.4	2,937.9	518.8	886.3	137.2	883.8	29.2	13.3	6,064.1
Utah	105.3	40.8	607.0	23.8	29.7	9.9	99.5		2.3	918.3
Vermont			101.9	8.2	51.6		60.8		6.5	229.0
Virginia	55.1	203.4	116.2	107.2	357.9	13.7	487.7		4.3	1,345.5
Washington	171.0		371.6				307.5		4.3	854.4
West Virginia	272.6	3.9	25.4	4.8	170.8	22.9	170.0	11.4	1.5	683.3
Wisconsin	146.3	84.0	1,011.1	6.7	13.8	.5	791.3		2.4	2,056.1
Wyoming	523.3	483.3	581.6	21.4	21.2	22.1	15.9		5.7	1,674.5
Hawaii					11.5	8.6	19.0		.4	39.5
Total	11,667.6	7,033.3	28,991.1	1,615.7	4,844.8	2,193.8	20,617.6	865.8	266.9	78,096.6

TABLE 21.—*Mileage of Federal-aid roads initially completed during the fiscal year 1929, by types of construction, by States* [1]

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	77.5	8.1	64.5			0.1	31.2		2.1	183.5
Arizona	64.5	−14.6	12.0			3.0	.4		.8	66.1
Arkansas	53.1		34.4				18.3		2.9	108.7
California	19.1		50.6	4.9	31.0	25.1	39.0		2.0	171.7
Colorado	29.2		62.0	5.3			74.7		3.9	175.1
Connecticut					1.6		19.6		1.6	22.8
Delaware							13.4			13.4
Florida	.2		15.7	15.9		11.7	19.8		.3	63.6
Georgia	23.3	17.1	.1	37.1	7.5	16.3	12.0		.2	113.6
Idaho	16.6		119.9			5.6	8.3		.4	150.8
Illinois	43.4						158.9		.9	203.2
Indiana	3.0						199.7		.4	203.1
Iowa	−3.2		22.4				103.7		.2	123.1
Kansas	180.2	63.5	6.4		11.6		66.4	9.4	1.1	338.6
Kentucky	106.7		7.8		19.7	13.5	20.2		1.1	169.0
Louisiana	5.0		21.8				17.1		2.6	46.5
Maine			22.8	8.5	10.5		9.8		.2	51.8
Maryland					40.2	5.1	25.2			70.5
Massachusetts			.1	3.1	49.3	9.0	8.4		−.2	69.7
Michigan			8.3	.1			145.3		.1	153.8
Minnesota	182.8						73.6		.6	257.0
Mississippi	34.2		74.5		.6	.9	−2.3		1.6	109.5
Missouri	47.3	2.6	1.6				47.3		.8	99.6
Montana	15.4		225.5	−1.9			4.0		1.2	244.2
Nebraska	114.3	341.9				.4	2.1		1.5	460.2
Nevada	8.3		111.1		27.3		.3			147.0
New Hampshire				3.8	4.3		21.0		−1.0	28.1
New Jersey			.9			.4	43.1			44.4
New Mexico	34.1		91.3				11.0		1.2	137.6
New York	8.7		20.5		3.3		286.2		.2	318.9
North Carolina	15.1						110.1		.4	125.6
North Dakota	365.6	3.0	131.6						.4	500.6
Ohio	44.9		1.2	8.1	32.5	3.4	75.6	34.5	1.0	201.2
Oklahoma	156.3				26.5		49.7		.8	233.3
Oregon	16.4		14.9		10.7				1.0	43.0
Pennsylvania	47.8						200.6		1.6	250.0
Rhode Island					18.9	2.5	7.5		.1	29.0
South Carolina		27.2	13.9			15.9	38.4		3.4	98.8
South Dakota	97.3	9.3	343.6						.5	450.7
Tennessee	28.7				−.1	7.0	35.1		2.1	72.8
Texas	114.4		12.8	−.1	4.0		101.8		2.4	235.3
Utah	10.5		74.6		6.7		7.9		.1	99.8
Vermont			5.5		5.9		16.1		.1	27.6
Virginia		10.9			55.0	3.1	15.3		.5	84.8
Washington	30.2		27.5				18.8		.2	76.7
West Virginia	57.6		5.5		11.1		19.7		.2	94.1
Wisconsin	−1.3	9.5	93.9			.4	107.4		1.1	211.0
Wyoming	150.9		56.3	.2	11.4				.8	219.6
Hawaii					−8.7	8.6	3.2		.2	3.3
Total	2,198.1	478.5	1,755.5	85.0	380.8	132.0	2,284.9	43.9	43.6	7,402.3

[1] Net decreases in mileage of certain types due to abandonment and revision of plans indicated by minus sign.

TABLE 22.—*Mileage of Federal-aid roads under initial construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	168.2		38.3				16.6		1.6	224.7
Arizona	98.4				0.8				1.3	100.5
Arkansas	28.5		37.3			4.2	30.6		2.3	102.9
California	53.7		56.0		79.0	29.0	46.2	0.1	1.4	265.4
Colorado	9.4		75.3		10.8		32.3		1.0	128.8
Connecticut					10.9		1.6			12.5
Delaware				8.0			7.7			15.7
Florida	38.7			16.1	7.1		28.0		1.0	90.9
Georgia	29.0	6.9			70.7		57.0		.3	163.9
Idaho	5.4		56.5		15.5				.1	77.5
Illinois	62.8		1.0				500.9	6.2	1.9	572.8
Indiana	12.8						262.7		.4	275.9
Iowa			5.0				48.4			53.4
Kansas	210.8	.2	3.5		4.5		22.4		2.4	243.8
Kentucky	181.4		19.5		25.7		16.1		1.1	243.8
Louisiana	44.6		105.0						2.3	151.9
Maine			2.0	16.2	9.6		15.4		1.1	44.3
Maryland							3.5		.1	3.6
Massachusetts					72.8	11.7	6.3		.3	91.1
Michigan	24.7		29.7				195.0		1.9	251.3
Minnesota	196.9						.3		.4	197.6
Mississippi	90.1		60.6				41.2		4.5	196.4
Missouri	111.6	4.4					93.7		2.1	211.8
Montana	5.8		321.2		26.2				1.0	354.2
Nebraska	106.5	119.1			9.5		4.6		.8	240.5
Nevada			108.2		6.3					114.5
New Hampshire				.6	1.9		10.0			12.5
New Jersey	4.6		.9		.4	.4	48.0			54.3
New Mexico	36.6		39.3	22.3	36.8		1.1		1.5	137.6
New York	22.8		10.8		57.0		253.0			343.6
North Carolina		32.4	17.0				30.7		.3	80.4
North Dakota	386.9		76.9	17.3					1.4	482.5
Ohio	41.5		8.5	3.4	30.3	1.9	140.9	28.7	2.0	257.2
Oklahoma	64.5						13.7		.6	78.8
Oregon	44.2				3.5				.5	48.2
Pennsylvania	10.6						178.2	13.2	.5	202.5
Rhode Island					13.3	4.1	6.4		.1	23.9
South Carolina	28.9	44.8				1.5	52.9		.8	128.9
South Dakota	340.3	16.8	130.4				.3		.8	488.6
Tennessee	84.4						33.3		2.1	119.8
Texas	495.8		14.1	11.2		17.3	111.9	1.0	6.6	657.9
Utah	39.1		23.4	3.5			1.8		.2	68.0
Vermont			.3				37.4		.4	38.1
Virginia	30.2	12.6	18.7		16.9	8.4	7.6		.9	95.3
Washington	49.9		22.7						.5	73.1
West Virginia	35.1	3.3			13.7		16.5		.3	68.9
Wisconsin	1.4		87.5				216.1		2.1	307.1
Wyoming	149.1		5.5						.5	155.1
Hawaii	1.7				4.8				.1	6.6
Total	3,346.9	240.5	1,375.1	98.6	528.0	78.5	2,590.3	49.2	51.5	8,358.6

TABLE 23.—*Mileage of Federal-aid roads approved for initial construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama							6.4			6.4
Arkansas	6.6		8.2				10.4		0.1	25.3
California	9.3		4.1		13.9		3.4		.9	31.6
Colorado			18.3		7.5					25.8
Connecticut				0.6			6.0		1.4	8.0
Delaware			4.8				26.0			30.8
Georgia				.6	2.3					2.9
Idaho	3.6		12.7							16.3
Illinois							22.5			22.5
Indiana							35.3			35.3
Iowa	.3						25.4			25.7
Kansas	130.3						5.1		.5	135.9
Kentucky	27.9		6.4		5.9				.1	40.3
Louisiana									.2	.2
Maine			10.8	2.0	12.2		4.7			29.7
Maryland							39.3			39.3
Massachusetts							1.9			1.9
Michigan							51.5		.1	51.6
Minnesota	64.1		10.6							74.7
Mississippi	12.7								.2	12.9
Missouri	1.2						15.3			16.5
Montana	48.2		111.0		6.2				.6	166.0
Nebraska	11.3	36.6					6.0		.1	54.0
Nevada					.6					.6
New Hampshire							6.5			6.5
New Jersey							8.7			8.7
New Mexico			9.0							9.0
New York	22.1				23.2		92.2			137.5
North Carolina			9.1			0.9	4.2			14.2
North Dakota	122.3	.6	1.0				.8			124.7
Ohio	12.2						47.1		.4	59.7
Oklahoma	11.1					4.9	22.1		.3	38.4
Oregon	39.6		13.1		19.8				.4	72.9
Pennsylvania	5.6						76.3			81.9
Rhode Island							1.5			1.5
South Carolina							14.2			14.2
South Dakota	29.9		19.0						.1	49.0
Tennessee	15.9									15.9
Texas	109.1					.9	60.4		2.8	173.2
Utah	2.2		16.2							18.4
Vermont									.1	.1
Virginia	1.6		3.7				16.8			22.1
Washington	4.2		11.9				5.8			21.9
West Virginia					9.9		14.6		.3	24.8
Wisconsin	10.0		9.9				19.0			38.9
Wyoming	28.7									28.7
Hawaii					16.6					16.6
Total	730.0	37.2	279.8	3.2	118.1	6.7	649.4		8.6	1,833.0

TABLE 24.—*Mileage of Federal-aid stage construction completed during the fiscal year 1929, by types of construction, by States*[1]

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama		1.3					66.9			68.2
Arizona	5.9		—4.3		13.6	8.5			0.3	24.0
Arkansas	2.8			0.6	1.0		4.9			9.3
Colorado						9.1	4.7		1.0	14.8
Connecticut									.1	.1
Delaware								3.9		3.9
Georgia				20.1	10.0		15.0		.1	45.2
Idaho			51.4		15.1					66.5
Indiana							3.5			3.5
Iowa			20.5				150.0			170.5
Kansas	.6						22.3			22.9
Maryland					7.2		3.6			10.8
Massachusetts									.2	.2
Michigan									.3	.3
Minnesota	73.0						44.9			117.9
Mississippi			6.6				24.3			30.9
Missouri	—2.7						66.8		.1	64.2
Montana			10.5			2.9				13.4
Nebraska	.2	179.0			1.5		1.6		.2	182.5
Nevada				—13.9	74.7					60.8
New Mexico			5.1						.5	5.6
New York							8.5			8.5
North Carolina		4.0					21.6			25.6
North Dakota	4.5		326.8							331.3
Ohio					.1		11.8		.2	12.1
Oklahoma					—7.7	23.6	28.1			44.0
South Carolina					7.7	35.9	46.7			90.3
South Dakota			116.6		4.0		4.5			125.1
Tennessee							118.6			118.6
Texas	8.2		8.1	14.2	12.0		154.4		.3	197.2
Utah			.5	7.0	22.3					29.8
Virginia							6.3			6.3
Washington			.1				4.9			5.0
Wisconsin							35.7		.1	35.8
Wyoming			27.1	5.6	9.8				.1	42.6
Total	92.5	184.3	569.0	[1]33.6	171.3	80.0	849.6	3.9	3.5	1,987.7

[1] Net decreases in mileage of certain types due to abandonment and revision of plans indicated by minus sign.

TABLE 25.—*Mileage of Federal-aid roads under stage construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitumi-nous mac-adam	Bitumi-nous concrete	Portland cement concrete	Bridges	Total
Alabama	21.0								21.0
Arizona	15.9				14.0			0.2	30.1
Arkansas							6.2	.3	6.5
California							9.2	.7	9.9
Colorado				15.0			10.4	1.2	26.6
Florida					5.4			.3	5.7
Georgia			7.8		15.2		13.9		36.9
Iowa			15.2				67.1		82.3
Kentucky					3.4				3.4
Minnesota	11.2						82.2		93.4
Mississippi	13.0		3.2				1.1	.1	17.4
Missouri	10.9						45.1	.2	56.2
Montana			3.3	4.1				.7	8.1
Nebraska		59.9						.3	60.2
Nevada					112.4				112.4
New Hampshire							1.0		1.0
North Carolina							7.2		7.2
North Dakota	20.0		102.1	15.7			.4		138.2
Oklahoma							5.8		5.8
Pennsylvania							14.1		14.1
South Carolina						22.2	15.1	.1	37.4
South Dakota	25.2		3.0		5.5		13.9	.1	47.7
Texas					82.4		170.4	.4	253.2
Virginia						15.1	3.7	.1	18.9
Washington	18.1								18.1
West Virginia			15.3				2.5		17.8
Wisconsin							28.8	.5	29.3
Wyoming	8.9								8.9
Total	144.2	59.9	149.9	34.8	238.3	37.3	498.1	5.2	1,167.7

TABLE 26.—*Mileage of Federal-aid roads approved for stage construction on June 30, 1929, by types of construction, by States*

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitumi-nous mac-adam	Bitumi-nous concrete	Portland cement concrete	Bridges	Total
Alabama							14.3		14.3
Arizona	28.9				0.5				29.4
Arkansas							6.0		6.0
California	7.3		3.9				8.3		19.5
Colorado				6.6	5.8				12.4
Iowa							63.9		63.9
Kansas	1.5						10.0		11.5
Louisiana							8.2		8.2
Maryland							16.8		16.8
Massachusetts							2.7	0.7	3.4
Michigan							9.5		9.5
Minnesota							16.6		16.6
Missouri							91.4		91.4
Nebraska		115.3	1.9				17.5		134.7
Nevada					92.4				92.4
North Dakota			222.0	9.9					231.9
Ohio							19.2	.1	19.3
Oklahoma						6.6	10.5		17.1
Oregon					44.6			.2	44.8
South Dakota	1.2		27.4						28.6
Texas	9.2		12.6				117.2	.1	139.1
Virginia							3.1		3.1
Washington			11.7						11.7
West Virginia							12.3		12.3
Wyoming			10.3		17.1				27.4
Total	48.1	115.3	289.8	16.5	160.4	6.6	427.5	1.1	1,065.3

TABLE 27.—*Net changes in the types of Federal-aid improvements on the Federal-aid highway system during the fiscal year 1929* [1]

State	Graded and drained	Sand-clay	Gravel	Water-bound mac-adam	Bitu-minous mac-adam	Bitu-minous concrete	Portland cement concrete	Brick	Bridges	Total
Alabama	77.3	9.4	25.7			0.1	98.1		2.1	212.7
Arizona	56.3	−14.7	−31.8		13.6	11.5	.5		1.1	36.5
Arkansas	53.2		−3.8		−3.1		18.1		2.5	66.9
California	21.9		41.4	5.4	31.9	23.5	43.9		2.0	170.0
Colorado	6.2		54.3	5.3		9.0	79.4		3.9	158.1
Connecticut					1.7		19.6		1.5	22.8
Delaware				−.1			13.4	3.9		17.2
Florida	.2	−.2	−69.8	101.3		11.6	19.8		.3	63.2
Georgia	6.9	4.8	−22.9	57.3	17.5	16.3	27.1		.2	107.2
Idaho	16.4	−7.9	168.7		15.8	5.7	8.3		.4	207.4
Illinois	43.4				−.1		159.0		.9	203.2
Indiana	3.0						203.1		.5	206.6
Iowa	−126.6		50.4				253.6	−.1	.3	177.6
Kansas	156.3	63.5	6.4		11.6	−.1	88.8	9.4	1.2	337.1
Kentucky	103.3		7.7		19.7	13.6	20.2		1.1	165.6
Louisiana	5.0		20.7				17.1		2.6	45.4
Maine			22.8	8.6	10.4		9.8		.2	51.8
Maryland				1.0	35.6	5.1	28.7			70.4
Massachusetts			.1	3.1	49.4	9.0	8.4		−.4	69.6
Michigan	.1		−6.2	−2.6		−3.9	145.1		.4	132.9
Minnesota	195.8		−260.8				113.1		.7	48.8
Mississippi	21.1	.1	76.8		.5	.9	21.9		1.6	122.9
Missouri	12.2	2.6	−48.1	−4.4	−6.0		110.8		.9	68.0
Montana	4.6		229.1	−1.9	−.1	2.8	4.1		1.0	239.6
Nebraska	89.3	516.7	−16.2		1.5	.4	2.4		1.7	595.8
Nevada	−.2	−4.3	−20.9	−13.9	101.9		.3		.1	63.0
New Hampshire				3.8	3.8	−.5	20.9		−.9	27.1
New Jersey			.9			.4	43.0			44.3
New Mexico	28.9		86.6				11.0		1.3	127.8
New York	8.7		11.9		3.4		293.7		.2	317.9
North Carolina	15.1	−10.2	−7.3				131.6		.4	129.6
North Dakota	84.5	−21.8	457.9	.1						520.7
Ohio	39.0		1.2	8.0	32.6	3.4	87.3	34.6	1.1	207.2
Oklahoma	113.0				18.7	23.6	77.9		.8	234.0
Oregon	16.3		14.9		10.8				1.0	43.0
Pennsylvania	33.7					−.1	200.7		1.6	235.9
Rhode Island					19.0	2.5	7.5			29.0
South Carolina	.1	26.3	7.6		7.7	51.8	85.2		3.5	182.2
South Dakota	40.4	9.3	417.7		4.0		4.5		.5	476.4
Tennessee	−89.9			.1	−.1	7.0	153.6		2.1	72.8
Texas	−138.2	−.1	−48.9	10.4	16.0		256.2	.1	2.7	98.2
Utah	10.6	−.9	58.1	7.0	29.0		7.9		.1	111.8
Vermont			5.5		6.0		16.1		.1	27.7
Virginia	.1	11.0	−3.7	−5.1	51.3	3.1	21.5		.5	78.7
Washington	25.3		27.6				23.6		.2	76.7
West Virginia	45.2		5.5	−.1	11.1	−5.3	19.8		.2	76.4
Wisconsin	−62.3	−20.4	−31.1	−.1	.1	.5	121.5		1.0	9.2
Wyoming	140.1	−.8	64.8	5.9	21.2				.9	232.1
Hawaii					−8.8	8.6	3.2		.3	3.3
Total	1,056.3	562.4	1,292.8	189.1	527.6	200.5	3,101.3	47.9	44.4	7,022.3

[1] Net decreases in mileage of certain types due to abandonment and revision of plans indicated by minus sign.

TABLE 28.—*Federal-aid apportionment, and amounts paid to the States for the fiscal year 1929, and the unobligated balance of the total apportionment on June 30, 1929*

State	Apportionment fiscal year 1929	Paid to States during the fiscal year 1929	Unobligated balances of total apportionment on June 30, 1929
Alabama	$1,547,483.00	$1,627,208.67	$2,243,381.25
Arizona	1,059,081.00	1,309,267.51	2,653,890.02
Arkansas	1,281,785.00	1,377,002.44	2,104,522.21
California	2,486,415.00	3,433,055.14	821,207.18
Colorado	1,383,401.00	1,803,610.66	1,673,794.83
Connecticut	474,213.00	1,059,461.12	558,722.80
Delaware	365,625.00	142,185.23	47,336.16
Florida	901,311.00	894,258.16	1,965,926.62
Georgia	1,980,015.00	1,446,496.98	2,018,492.49
Idaho	932,962.00	1,270,906.07	856,815.71
Illinois	3,135,225.00	5,682,636.43	2,642,000.00
Indiana	1,921,463.00	2,374,265.04	134,519.81
Iowa	2,035,291.00	2,704,154.16	
Kansas	2,062,196.00	2,005,221.08	1,144,315.96
Kentucky	1,421,029.00	1,504,667.75	757,788.11
Louisiana	1,019,282.00	886,011.42	1,150,105.07
Maine	681,431.00	229,792.30	1,111,122.42
Maryland	634,906.00	712,060.20	213,725.37
Massachusetts	1,088,808.00	825,636.10	1,787,319.03
Michigan	2,209,596.00	3,090,670.12	1,424,179.67
Minnesota	2,112,595.00	2,216,048.53	410,000.00
Mississippi	1,309,729.00	1,306,196.99	1,361,970.25
Missouri	2,404,347.00	2,422,487.79	136,556.02
Montana	1,552,576.00	1,923,168.90	3,613,761.84
Nebraska	1,584,981.00	1,225,896.80	2,539,681.66
Nevada	957,995.00	863,467.12	204,689.18
New Hampshire	365,625.00	365,278.82	188,125.54
New Jersey	935,122.00	768,902.44	625,470.08
New Mexico	1,189,361.00	2,106,513.24	1,153,455.48
New York	3,629,879.00	3,761,689.93	4,295,740.58
North Carolina	1,715,910.00	1,716,874.85	1,721,786.21
North Dakota	1,193,440.00	1,325,962.17	982,621.03
Ohio	2,757,964.00	3,937,359.91	2,755,365.68
Oklahoma	1,749,066.00	1,614,336.80	913,425.83
Oregon	1,189,707.00	544,205.11	1,430,698.62
Pennsylvania	3,333,786.00	3,801,073.14	1,855,478.52
Rhode Island	365,625.00	402,771.00	548,347.68
South Carolina	1,059,533.00	816,484.11	886,629.83
South Dakota	1,223,981.00	1,107,488.48	371,595.94
Tennessee	1,612,012.00	2,245,874.99	1,096,306.59
Texas	4,502,576.00	4,191,191.70	36,517.80
Utah	848,093.00	1,066,011.51	361,621.97
Vermont	365,625.00	406,248.51	62,786.68
Virginia	1,437,548.00	1,297,653.57	758,318.82
Washington	1,143,226.00	1,498,282.57	917,100.03
West Virginia	793,796.00	1,090,621.80	77,371.86
Wisconsin	1,864,212.00	2,438,786.46	338,759.36
Wyoming	939,547.00	1,165,778.45	313,862.69
Hawaii	365,625.00	92,158.11	1,072,664.16
Total	73,125,000.00	82,097,380.38	56,339,874.64

NATIONAL FOREST ROAD CONSTRUCTION

In the forest road system there are 14,165.7 miles, of which 12,014.5 miles are in the States of the mountain and Pacific groups and Alaska. All appropriations for forest roads are expended upon this system.

As shown by Table 29, the mileage of class 1 highways, upon which it is planned to expend approximately 70 per cent of each annual appropriation until they are completed, is now 1,144.4 miles, of which 822.6 miles are in the Western States. These are the more important highways which are necessary sections or extensions of the Federal-aid system wholly within the forest areas. The class 2 highways which also extend the Federal-aid system, are increased by recent additions to a total of 7,256.6 miles, of which 7,018.5 miles are in the West. The class 3 highways, those that serve principally the communities within the forests now aggregate 5,764.7 miles, of which 4,173.4 miles are in the Western States and Alaska.

TABLE 29.—*Classified mileage of forest highway system, by States*

State	Mileage of forest highway system			
	Class 1	Class 2	Class 3	Total
Western:				
Alaska			378.8	378.8
Arizona	174.0	491.0	243.0	908.0
California	321.5	989.6	784.9	2,096.0
Colorado		1,228.0	495.0	1,723.0
Idaho		738.1	351.1	1,089.2
Montana	147.4	657.2	381.0	1,185.6
Nevada		376.4	97.0	473.4
New Mexico	115.0	211.0	199.0	525.0
Oregon	58.0	872.4	441.0	1,371.4
South Dakota	2.0	169.0	63.0	234.0
Utah		458.0	299.0	757.0
Washington	4.7	472.8	311.6	789.1
Wyoming		355.0	129.0	484.0
Total	822.6	7,018.5	4,173.4	12,014.5
Eastern:				
Alabama			41.0	41.0
Arkansas	131.0	51.0	20.0	202.0
Florida		.7	106.0	106.7
Georgia			99.0	99.0
Maine			11.0	11.0
Michigan		13.4	55.0	68.4
Minnesota	41.0	38.5	142.0	221.5
Nebraska			28.8	28.8
New Hampshire	18.3	15.5	56.5	90.3
North Carolina	49.0		199.0	248.0
Oklahoma			33.0	33.0
Pennsylvania	24.5		173.0	197.5
South Carolina		6.0	40.0	46.0
Tennessee	58.0	71.0	169.0	298.0
Virginia		38.0	269.0	307.0
West Virginia		4.0	149.0	153.0
Total	321.8	238.1	1,591.3	2,151.2
Grand total	1,144.4	7,256.6	5,764.7	14,165.7

As shown by Table 30, the improvement of 315.4 miles of forest highways of all classes was completed during the year. Of this total 298.1 miles were in the Western States and Alaska, and the remaining 17.3 miles were in the forests of two Eastern States.

The total mileage upon which improvements have been completed to date, including the results of the last year's work, is 4,090.7 miles, of which 3,782 miles are in the West and 308.7 miles in the East.

TABLE 30.—*Mileage of completed forest highway projects, by States*

State	Mileage of forest highway projects completed.		State	Mileage of forest highway projects completed.	
	During 1929	Total to June 30, 1929		During 1929	Total to June 30, 1929
Western:			Eastern:		
Alaska	19.6	204.5	Alabama		5.1
Arizona	46.7	307.9	Arkansas	3.1	59.8
California	32.8	316.9	Florida		64.2
Colorado	23.8	332.2	Georgia		21.4
Idaho	21.9	484.3	Michigan		8.1
Montana	2.6	367.2	Minnesota	14.2	48.8
Nevada	2.8	110.8	New Hampshire		3.6
New Mexico	17.5	188.1	North Carolina		36.3
Oregon	73.2	647.1	South Carolina		16.0
South Dakota	1.5	46.2	Tennessee		33.5
Utah	15.9	300.9	Virginia		11.9
Washington	19.9	215.9			
Wyoming	19.9	260.0	Total	17.3	308.7
Total	298.1	3,782.0	Grand total	315.4	4,090.7

Although the mileage upon which improvements were completed during the year exceeds the mileage completed during the preceding year by more that 12 per cent, the increase is incidental rather than the result of any enlargement of the construction program. The latter is limited by the amount of the annual appropriations authorized, which have been unchanged for several years.

The policy of restricting the greater part of the expenditure to the improvement of the major roads within the forests is in accord with the similar policy which has yielded such satisfactory results in the improvement of the State roads. But even when so restricted the sums available annually for forest-road construction do not permit the improvement of the system at a rate consistent with the improvement of the roads outside the forest areas. With less than a third of the system improved to any degree, and much that has been improved in need of further improvement, it will be many years before the entire system can be adequately constructed at the present rate, and meanwhile the inadequacy of the forest roads will be thrown into sharper relief by the rapidly improving condition of the Federal-aid and State roads with which they connect. Under the present circumstances the most that can be done to serve the increasing traffic upon a large portion of the mileage is to keep the roads passable by maintenance, and this will be done. But increased appropriations are urgently needed if the roads through the forest areas are to be prevented from becoming serious obstacles in the path of a rapidly increasing traffic.

Among the more important improvements completed during the fiscal year are sections of the Johnson Pass, Point Agassiz, and Texas Creek highways in Alaska; the Pine-Long Valley highway in Arizona; the Howard Road in Arkansas; the Bear Valley, Idyllwild, Quincy-Beckwith, and Truckee-Myers highways, and the San Marcos extension in California; the Eagle-Thomasville, Mount Evans, and Ward-Raymond highways, and the road from Nederland to State route 26 in Colorado; the Enarville-Murray project, and the Lewis and Clark, Sawtooth Park, and Victor-Irwin highways in Idaho; the Grand Marais-Gunflint, and Winnibigoshish Dam-Bena Road projects in Minnesota; and in Montana the Clark Fork and Columbia Falls-Glacier Park projects.

In Nevada the Glenbrook-Spooners section of the Glenbrook highway has been completed; and in New Mexico a section of the Datil-Reserve-Dry Creek project. Also completed are sections of the Canyon City-Burns, Heppner-Spray, John Day-Pilot Rock, Mount Hood-Wapinitia and Salmon River highways in Oregon; the Deadwood-Custer-Hot Springs highways in South Dakota; the mountain section of the Vernal-Manila highway in Utah; the Metaline and Tonasket-San Poil highways in Washington; and the Dayton-Kane, Encampment-Slater, Granite Creek-Shell, and Jackson Park highways in Wyoming.

The construction of a number of important bridges was also completed during the year. Among these may be mentioned a railroad overpass on the Truckee-Myers project in California; the bridges on the Pritchard section of the Enarville-Murray project in Idaho, and in the same State the Sinclair Bridge and its approaches, and the Ketchum-Clayton Bridge; the bridge over Hell Roaring Creek on the West Gallatin project and the bridges on the Saltese section of the Yellowstone Trail in Montana; and in Washington the Sullivan Creek bridges on the Metaline highway.

Additional work involving surfacing and in some cases reconstruction was completed on the following projects: In Alaska, the Moose Pass, Salmon River, Tongass, Glacier, and Petersburg highways; in Arizona, the Main-Grand Canyon Highway; in California, the Truckee-Myers Highway; in Colorado, the Berthoud Pass Highway; in Montana, several sections of the West Gallatin Highway and the Y. G. B. Line Highway; in New Mexico, the Cimarron-Taos, Navajo Canyon, Alpine Reserve, and Canoncito-Pecos highways; in Oregon, the John Day-Pilot Rock, Klamath Falls-Lakeview, Santiam, and Oregon Caves highways; in Utah, the Cedar-Long Valley, and Heber-Fruitland projects; in Washington, the Lake Chelan extension; and in Wyoming, the Teton Pass section of the Teton Highway.

ROAD CONSTRUCTION IN THE NATIONAL PARKS

In the national parks where the bureau is supervising the improvement of the more important roads under an agreement with the National Park Service of the Department of the Interior, the year's work brought to completion the improvement of 100.7 miles

of park roadway, increasing the total thus far improved to 213.4 miles. At the close of the year construction was in progress on 113 miles and surveys were under way on 209 miles more.

This work is directed toward the eventual improvement of a system of major park roads in which there are now included 1,509.7 miles. The mileage included in the system and the parks within which it is located, together with the record of completion during the last year and to date, are shown in Table 31.

TABLE 31.—*The program of national-park road improvement, and the mileage of roads improved under the supervision of the Bureau of Public Roads*

National park	Mileage of the program	Mileage completed under the supervision of the bureau	
		During the fiscal year 1929	Total to June 30, 1929
Crater Lake	70.5	3.8	21.4
Glacier	145.9	24.6	30.2
Mount Rainier	122.1	2.2	14.0
Grand Canyon	156.7	25.6	33.9
Yosemite	218.6	.5	27.9
Sequoia	84.5	4.3	23.2
General Grant			4.0
Lassen Volcanic	39.5	7.8	13.6
Rocky Mountain	64.4	6.9	8.7
Devil's Tower National Monument	1.6		.3
Yellowstone	369.2	20.4	20.4
Zion	22.4	4.6	4.6
Hawaii	83.6		11.2
Mesa Verde	47.3		
Acadia	4.5		
Wind Cave	5.4		
Mount McKinley	73.5		
Total	1,509.7	100.7	213.4

Of outstanding interest among the projects completed during the year are the East Rim Road in Zion Park, and the west side section of the Transmountain Highway in Glacier Park. Both of these projects involved construction of an exceptionally difficult order. In the 4.6-mile length of the former there is more than a mile of tunnel; in the latter the road is hewn out of the rock face of the famous Garden Wall.

Both are of great importance aside from their value as means of developing and giving access to previously isolated portions of the parks. The Zion Park road is a link in the new route which will eventually connect the railhead at Cedar City, Utah, with the north rim of the Grand Canyon in Arizona, and thence by way of the House Rock Valley and the new Lees Ferry Bridge with the Arizona road system south of the canyon. The Transmountain Highway, as its name implies, will connect the two sides of Glacier Park and the adjoining country hitherto separated by the impassable mountain wall.

Other important projects brought to completion during the year are the Anna Springs-Crater Lake Highway in Crater Lake Park; the Babb section of the Babb-Many Glacier Highway in Glacier Park; the Grand View section of the Grand Canyon-Grand View Road, the south entrance road, and the Village and Yacqui Point spur roads in Grand Canyon Park; the southwest entrance and summit sections in Lassen Volcanic Park; the White River section of the Yakima Park Road in Mount Rainier Park; the Bear Lake project in Rocky Mountain Park; three sections of the General's Highway in Sequoia Park; and in Yellowstone Park, the Gibbon Canyon and West Gallatin roads and a section of the Sylvan Lake-Lake Butte Road.

RESTORATION OF FLOOD-DAMAGED ROADS IN SEVERAL STATES

In the agricultural appropriation act for the fiscal year 1929, approved May 16, 1928, appropriation was made as a contribution in aid from the United States for the relief of the States of Vermont, New Hampshire, and Kentucky which suffered serious loss through the damage and destruction of roads and bridges by the floods of 1927. The act provided that the sums appropriated should be expended by the State highway departments of the respective States with the approval of the Secretary of Agriculture for the restoration of the roads and bridges damaged or destroyed, in such manner as to give the largest measure of permanent relief. To obtain the benefit of the Federal appropriation the three States were required by the act to appropriate from State funds an amount equal to the contribution of the Government.

A similar appropriation was made by the War Department appropriation act for the fiscal year 1930, approved February 28, 1929, for the relief of

the States of Missouri, Arkansas, Louisiana, and Mississippi in consideration of the damage to roads and bridges caused by the heavy flood in the Mississippi River and its tributaries in the same year.

As required by these acts, rules and regulations for carrying out their purposes were promulgated by the Secretary of Agriculture, for the first mentioned on June 26, 1928, and for the second on April 19, 1929.

The several States have complied with the requirements of the two acts with respect to the appropriation of equal State funds; and the work of restoration is well advanced in Vermont, New Hampshire, and Kentucky. A considerable part of the money appropriated to each of these States has been obligated to definite projects and payments have been made in the amounts hereafter reported for work done. In the Mississippi Valley States the work was later in getting under way and no payments from Federal funds have yet been made.

The appropriations made for the relief of the several States were as follows: For the State of Vermont, $2,654,000; for the State of New Hampshire, $653,000; for the State of Kentucky, $1,889,994; and for the States of Missouri, Arkansas, Louisiana, and Mississippi, the total sum of $3,654,000.

The amounts of the respective appropriations obligated to definite projects up to the close of the fiscal year in Vermont, New Hampshire, and Kentucky, and the amounts paid to each on the basis of work completed are shown in Table 32. The mileage of roads improved in each of these States up to June 30, and the corresponding total costs and Federal payments are shown in Table 33. Similar information with regard to other projects under construction and approved at the end of the fiscal year is given in Tables 34 and 35; and the mileage of the several types of roads completed, under construction, and approved for construction on June 30 is shown in Table 36.

TABLE 32.—*Flood relief appropriated, amounts paid to the States, and the unobligated balance of the appropriation on June 30, 1929*

State	Appropriated	Paid to the States to June 30, 1929	Unobligated balance
Vermont	$2,654,000	$1,654,646.53	$144,976.30
New Hampshire	653,000	107,141.90	21,177.33
Kentucky	1,889,994	155,336.53	1,502,298.78
Total	5,196,994	1,917,124.96	1,668,452.41

TABLE 33.—*Total cost, flood relief, and mileage of roads improved to June 30, 1929*

State	Total cost	Flood relief	Mileage
Vermont	$1,742,883.88	$858,783.70	21.1
New Hampshire	632,045.58	316,022.75	7.7
Total	2,374,929.46	1,174,806.45	28.8

TABLE 34.—*Total cost, flood relief, and mileage of roads under construction on June 30, 1929*

State	Total cost	Flood relief	Mileage
Vermont	$3,621,056.92	$1,650,240.00	37.5
New Hampshire	540,988.06	270,494.01	14.2
Kentucky	652,990.48	326,495.22	29.2
Total	4,815,035.46	2,247,229.23	80.9

TABLE 35.—*Total cost, flood relief, and mileage of roads approved for construction on June 30, 1929*

State	Total cost	Flood relief	Mileage
New Hampshire	$91,211.82	$45,605.91	1.6
Kentucky	160,900.00	61,200.00	15.1
Total	252,111.82	106,805.91	16.7

TABLE 36.—*Mileage of the various types of flood relief roads completed, under construction, and approved for construction, June 30, 1929, in the States of Vermont, New Hampshire, and Kentucky*

Type of construction	Vermont			New Hampshire			Kentucky	
	Approved for construction	Under construction	Completed	Approved for construction	Under construction	Completed	Approved for construction	Under construction
Graded and drained							15.1	29.1
Gravel		3.3	3.8					
Water-bound macadam		9.1			4.9	2.9		
Bituminous macadam		3.6				2.3		
Portland cement concrete		17.4	15.0	1.6	9.2	1.9		
Bridges and approaches		4.1	2.3		.1	.6		.1
Total		37.5	21.1	1.6	14.2	7.7	15.1	29.2

MOUNT VERNON MEMORIAL HIGHWAY

As the fiscal year closed the detailed surveys for the Mount Vernon Memorial Highway had been completed and plans for all parts of the road were well advanced. Every possible effort is being put forth in the development of the plans to make this road one of the most attractive in North America. The alignment as designed is a succession of long, easy curves; the grades rise and fall gently with the natural roll of the hills; the cut and fill banks will be cut to flat slopes and rounded so as to merge with the natural topograph; and the bridges of which there are several, including an important highway grade separation structure at the south end of the present highway bridge over the Potomac, will be graceful flat arches faced with native stone.

Special attention has been given to the provision of adequate parking space at Mount Vernon and at several points along the way, and to features of design and location which will afford a maximum of safety at intersecting and entering roads.

Some delay has been experienced in the procurement of rights of way along the river location which was selected as the line to be followed; but it is anticipated that it will be possible to begin construction of the hydraulic fill along the river's edge at the north end early in the next fiscal year, and that properties that still remain to be acquired will be had in time to permit continuance of the construction without further delay.

It is the purpose to complete the highway by 1932 in order that it may be officially opened and dedicated as an incident of the celebration of the bicentennial of the birth of Washington in that year.

INTERNATIONAL ROAD CONGRESS AND PAN AMERICAN HIGHWAY ACTIVITY

In preparation for the Sixth International Road Congress, which, at the invitation of the United States Congress, is to be held at Washington from October 6 to 11, 1930, there is a great deal of preliminary work to be done, much of which necessarily devolves upon the bureau, and this work, including the preparation of advance notices of the congress, the nomination of American engineers to serve as reporters upon the various subjects proposed for discussion, the making of arrangements for transportation of foreign delegates by steamship and railroad lines, has already been begun.

This congress will bring to the United States a large number of the best-qualified highway engineers of foreign countries for a discussion of road problems of mutual interest and concern to all countries.

The Sixth International Conference of American States, at Habana, Cuba, by resolution adopted by the conference, recommended to the Pan American Congress of Highways, which will meet at Rio de Janeiro in August of the present year, the consideration and adoption of agreements looking to the construction of a Pan American highway connecting the continents of North, Central, and South America.

By joint resolution, approved May 4, 1928, the United States Congress, taking cognizance of the above-mentioned resolution, requested the President to direct the several agencies of

the Government to lend such cooperation and assistance as may be feasible and appropriate with a view to having the matter of the proposed highway thoroughly considered by the approaching Pan American Congress.

By another joint resolution, approved March 4, 1929, Congress authorized the appropriation of $50,000 to enable the Secretary of State to cooperate with the several governments, members of the Pan American Union, in reconnaissance surveys to develop the facts, and to report to Congress as to the feasibility of possible routes, the probable cost, the economic service, and such other information as will be pertinent to the building of an inter-American highway or highways. It is expected that this bureau will be called upon to assist in such a survey when it is undertaken; but, owing to the fact that the appropriation authorized was not made at the last session of Congress, no definite action has yet been taken in response to the resolution.

Subsequently, however, the President appointed representatives of the United States to the Pan American Congress of Highways, naming me, as Chief of the Bureau of Public Roads, as one of the representatives. In connection with this appointment, it has been necessary to give some preliminary study to the feasibility of the proposed highway and other matters of mutual interest to the countries of the two continents which will be considered at the forthcoming congress.

TRAFFIC SURVEY ON FEDERAL-AID HIGHWAY SYSTEM IN THE WESTERN STATES

As the fiscal year closed, agreements had been negotiated between the bureau and the States of Washington, Oregon, California, Idaho, Nevada, Utah, Arizona, Wyoming, Colorado, New Mexico, and Nebraska, providing for the cooperation of the several States and the bureau in a comprehensive and coordinated survey of traffic on the Federal-aid highway system within these States.

In the course of the survey, which will cover a period of a year, the usage of all parts of the system in these States, involving a total of more than 33,000 miles, will be determined by periodic counts of the number of vehicles of all classes passing survey stations located at suitable points. In addition to showing the volume of traffic on each section of the system, at all seasons of the year, the data to be collected will also indicate the points of origin and destination of the traffic, and in each State the proportion of intrastate to interstate traffic.

Of considerable sentimental interest will be the indications of the survey concerning the present traffic on the historic western trails. Data will be obtained along the full length of the Oregon Trail from Omaha to Portland, first traveled by pioneer wagon trains in 1843. Many of these old routes of pioneer travel are now followed closely by modern roads on which the long-distance bus has taken the place of the stage coach of former days. The routes from Omaha to Denver, Salt Lake City, and San Francisco; from Denver to Santa Fe and Los Angeles; and the Pacific coast route from Seattle to Los Angeles are among those upon which data relating to bus transportation will be obtained.

The improvement of these main roads of the Western States has now progressed to such an extent as to permit of the utilization of practically all parts of the system without insurmountable obstruction or serious inconvenience, so that it may be assumed that in the main the relative importance of the various routes has been established by their usage. The determination of the extent of usage of each route and section of route at this time will therefore provide information of great value to guide the further improvement of the system.

The data to be collected in regard to the origins and destinations of vehicles will serve to indicate the extent to which the system as at present designated fails to furnish facilities for direct movement from point to point, thus indicating the need for the addition of new routes. This type of data will also give information as to the usage of the roads of each State by vehicles registered in other States, thus providing a measure of the amount of tourist travel, a matter of considerable interest to the Western States.

STUDIES OF HIGHWAY PRODUCTION PROBLEMS

In this field the work of the past year which is worthy of special mention has dealt with four problems as follows: (1) Development and improvement of such means and methods of field operation as will permit the best possible utilization of the full

production capacity of the equipment and organization; (2) effect on rate of production and unit costs of certain rather common practices in present-day highway work; (3) the application of production engineering methods to low-cost bituminous construction; and (4) development, in cooperation with the various State highway departments, of a uniform standard outline for a system of fiscal records and cost accounting.

Modern road building is essentially a manufacturing process in which large arrays of movable plant and equipment instead of stationary factories are utilized to produce a finished product in permanent place on the right of way instead of in producing goods in a factory. As in much manufacturing work, the daily cost of operating a modern road-building plant is nearly independent of the rate of production. Consequently, the most effective way to decrease unit production costs is to increase the rate of production. Thus, the studies of the bureau show that the daily cost of operating a modern concrete-paving plant is about $400 per day whether the daily production of pavement be 500 or 1,000 feet. If the daily production is only 500 feet, the operating cost is 80 cents per lineal foot, whereas if production is 1,000 feet per day the operating cost is reduced to 40 cents per lineal foot.

The question thus becomes: How can this higher rate of production be attained and maintained without impairing the quality of the finished product? The answer is found (1) in eliminating or reducing the time losses and waste motions connected with all direct operations; (2) in coordinating and synchronizing the rate of production of the various subsidiary operations with the key equipment; and (3) in finding ways and means of eliminating unnecessary operations and of expediting those which are really necessary.

But before the highway industry can profit from this work of the bureau the ways and means devised must be applied to actual field conditions. For this reason the engineers of the bureau work almost entirely on selected, typical, going projects and in cooperation with the contractor, his superintendent, and the various highway officials in charge of the work. The maintenance of quality is always the first consideration. Nothing is permitted which might in any way reduce the quality below that called for in the contract. With the maintenance of quality established as the first essential, the conditions are studied and analyzed until the causes of the low production are located, when the study changes to devising ways and means for their reduction or elimination. As an example of the success which is often met in this work of reducing time losses and synchronizing operations, mention may be made of a concrete-pavement project during the past season in Wisconsin. The average rate of production on this project when the bureau's engineers began their studies was 134 square yards of pavement per hour. After the causes of the low rate of production had been located and ways for their reduction had been pointed out to the contractor and put into effect the rate of production rose to an average of 202 square yards per hour—an increase of slightly more than 50 per cent in the rate of production, with practically no increase in the daily cost of operation. Not all projects on which work has been done present the possibility of such great improvement. But very few projects have been found on which an increase of 10 per cent or more in the rate of production was not possible without any corresponding increase in the cost of operation.

The number of contractors with whom the bureau can cooperate directly in such demonstrations is, of course, limited. Those whose projects are analyzed have brought to their notice means by which their practice may be made more efficient, and almost invariably they welcome the bureau's suggestions and benefit by them not only on the particular project studied but also in other contracts which they subsequently obtain. But the benefits of this work extend far beyond the partcular contractors and engineers with which the bureau cooperates directly. The several contractor's associations have manifested keen interest in the methods developed and the results obtained and through these associations the principles developed have been widely disseminated, thereby reaching and influencing the operations of an ever-widening circle of road builders. Engineers of the States and counties are apprised of the results of the studies through reports published in the bureau's journal of highway research, Public Roads, and by means of papers presented at national and local engineering meetings. In these ways the benefits of these studies have been widely extended, and the principles

and methods developed are being successfully applied by a large and increasing group of the most progressive and responsible contractors.

In road-grading work, solid rock, shale or hardpan is frequently encountered. Before materials of this character can be moved they must usually be blasted. Occasionally the blasting is such as to loosen and break up the material very well, but more often it is only sufficient to break the material into pieces too large to be readily handled by the power shovel. A study has recently been completed which shows that well-blasted rock or shale can be handled by a good power shovel about as fast as ordinary common excavation, but that poorly blasted rock reduces this average rate of operation by at least 30 per cent. In actual pay yardage as measured in the cut, the average decrease due to poor blasting is not less than 10 cubic yards per hour and may readily be three times as much. Furthermore, because of the excessive wear and tear on the equipment, the hourly operating cost of a power shovel is actually higher when working in poorly blasted material than when working in well-blasted material. Poor blasting, therefore, is at present a source of considerable direct and unnecessary expense to the grading contractor and to the taxpayer who must finally pay the cost. Naturally, the large extent of the loss has not been appreciated or the practice that causes it would not have been tolerated. The bureau will now undertake to bring about a correction of these practices by the various means that have been described above.

Attempts have been made during the past year to find effective ways and means of applying the principles of production engineering to the construction of low-cost bituminous roads. This type of construction is new and neither methods nor equipment have as yet attained any considerable degree of standardization. Some of the operations involved, such as the mixing of oil and stone particles in place on the road, present problems which have not arisen in connection with any other type of construction. Lacking equipment designed especially for the new purposes, available equipment intended for other purposes is being employed with obvious lack of efficiency. The bureau has undertaken a study of the problems presented by these new types of construction, and will endeavor to suggest means and equipment adapted to attain the ends sought with greater facility and economy than is at present possible.

During the past year the bureau has assisted several States in the installation of uniform accounting and statistical procedures designed to supply full and complete records of expenditures and accomplishments in the fields of highway construction, maintenance, and administration. Basically this work consists in making use of bookkeeping and tabulating machines and in the development of standard definitions of operations and of practices and the setting up of standardized accounts thereunder. Further developments of this work and adoption of such uniform systems of accounting by the several States will make possible comparison of the costs of construction and maintenance of roads as carried on in each of the States—a comparison which is not at present possible because of the dissimilar forms of records kept. Such comparisons when they can be accurately drawn will be helpful to all States as an index of the need for correction of their practice, and will be especially useful as a means of supplying data not now available with regard to the cost of maintaining the various types of roads under various conditions of traffic, climate, topography, and soil.

PHYSICAL RESEARCHES

SUBGRADE INVESTIGATIONS

In previous annual reports mention has been made of the subgrade investigations which have been carried on continuously for several years and which, on account of the fundamental nature of the problems involved, are considered as among the most important of the physical researches with which the bureau is concerned.

General experience and observation, supplemented by special investigations, have disclosed that the performance of road surfaces is greatly influenced by the stability of the subgrade, that is, its resistance to lateral flow under load; by volume changes in the subgrade material due to variations in moisture content; by its elastic properties; the degree of uniformity of the support which it furnishes; the occurrence of heaving due to frost action; and the presence or absence of certain chemical constituents.

The investigations which are being conducted have for their ultimate pur-

pose the determination of the physical laws governing the behavior of soils and the identification of the soil constituents which exert a major influence on behavior; the determination of the extent to which the characteristics of soils are influenced by their constituents and the extent to which they are influenced by the natural conditions in which the soils occur; the development and standardization of tests which will permit a laboratory identification of soils and the development of methods for identifying and mapping subgrade soils in the field; the classification or grouping of soils with respect to their efficiency as subgrades and the correlation of this grouping with the existing classification which has been developed for agricultural purposes; and the determination of methods for correcting undesirable subgrade conditions.

The procedure followed includes laboratory investigations of soils to learn the physical laws which govern stability, shrinkage, expansion, compressibility, elasticity, and heaving due to frost; and other laboratory investigations of the extent to which different tests disclose the physical characteristics of soils and permit the identification of the soil constituents upon which these characteristics depend. Closely correlated with these laboratory investigations there is a field examination of road failures involving variations in road type, character of soil and its moisture content, climate, and amount of traffic, recording for subsequent analysis the results furnished by these examinations with respect to type, design, age, and condition of road surface, drainage conditions, topography, the underlying soil profile, and the soil characteristics as disclosed by the laboratory tests. Similar observations are made of roads on which have been used such corrective measures as drainage improvements, subgrade treatments, and subbases; and the final stage will involve the construction and subsequent observation of experimental roads in which various corrective methods have been employed.

The investigations have been continued, as in the past, with the cooperation of the Bureau of Chemistry and Soils and various State highway departments and educational institutions.

The investigation of heaving due to frost action is illustrative of the manner in which the different problems are being attacked. It has been observed frequently that certain sections of pavement have heaved during cold weather to an extent much greater than can be explained by the expansion during freezing of the moisture originally present in the layer of frozen soil. In New Hampshire, with the cooperation of the State highway department and the Massachusetts Institute of Technology, observations of frost heaving have been made during the past two winters to determine climatic conditions, vertical displacement of the pavement, height of groundwater level, depth of frost penetration, and character of ice formation. Information regarding the character, condition, and arrangement of the underlying soil zones has also been obtained. In an extension of this study, designed to permit a better control of the variable factors, the behavior during freezing and thawing of New Hampshire soils, transported to the campus of the Massachusetts Institute of Technology, has been observed during one winter. These investigations have been supplemented at the University of South Carolina by controlled laboratory studies of the physical laws which control the growth of ice crystals during freezing, and at the Arlington Experiment Farm by observations of the rate of heat transfer through different types of pavements.

As a result of these studies it has been found that excessive heaving due to frost action is caused by segregation of the moisture as it freezes to form layers of solid ice, additional water, which is in turn frozen, being drawn up through the soil pores from the ground-water level below. Under conditions favorable to this action, very thick layers of ice may be formed. Much has been learned regarding the soil, moisture, and climatic conditions which promote the formation of these layers of ice and this knowledge suggests certain corrective measures which may be used to advantage.

The subgrade investigations are continuous in nature. Although definite accomplishments can now be reported, a vast amount of work remains to be done in the solution of the difficult problems which are encountered. During the year there has been published an instructive report summarizing much of the present knowledge of the subject and illustrating the possibilities of utilizing this knowledge as a

guide to the selection of proper pavement type and the proper design of the type selected.

LOW-COST BITUMINOUS ROAD INVESTIGATIONS

The investigations in the development of relatively inexpensive methods for the improvement of light-traffic roads are being continued and extended to meet the particular needs of various sections of the country.

An extensive inspection trip by two members of the bureau staff has been made through nine of the Western States for the purpose of observing the results which are being obtained in the oil treatment of crushed rock and gravel roads. As a result, arrangements have been made for the construction of two experimental roads, one in California and one in Nebraska.

As mentioned in the last annual report, these oil treatments have been used extensively in the Western States and with marked success. However, nearly all of this work has been done with light fuel oils and road oils and the experimental road in California is being built to study the possible utility of other materials such as asphaltic emulsions, asphaltic cements, and cutback asphalts. The road will be about 10 miles long and will include 20 experimental sections. The work is being done in cooperation with the division of highways of the California Department of Public Works.

A considerable portion of Nebraska is included in what is known as the "sand-hill area," in which there exists very little satisfactory road-building material. The natural soil in this area is a fine-grained sand, lacking in binding material and entirely unsuited to road construction in its natural condition. Some treatment is necessary in order to produce a road surface adequate even for the comparatively light traffic of the region. Treatments of extremely sandy soils with bituminous materials have been successful elsewhere, notably in California, and some preliminary experimental construction of limited extent in Nebraska has given promising results. In order to develop the methods and materials most suitable for use in connection with the sandy soils of this area arrangements have been made for the construction of an experimental road about 9 miles long in cooperation with the Nebraska Department of Public Works.

In South Carolina the cooperation with the State Highway Department in the bituminous treatment of sand-clay and topsoil roads has been continued and extended. Twenty-eight miles of experimental highways already constructed are under observation and 4½ miles of bituminous surfacing on sand-clay and marl bases is under construction.

To supplement the intensive studies carried on by means of the above-mentioned experiments, extensive surveys are in progress in which the results of methods of construction developed by State and local highway officials in all parts of the United States will be studied and compared. The common object of all such methods is the production of a bituminous road surface of moderate cost which will adequately serve light and medium traffic; but various materials have been used and various methods of combining the bituminous and nonbituminous constituents have been developed.

By careful study of the methods and materials used in various parts of the country, by comparison of the results obtained, and by disseminating the information gathered it is expected that the better methods and materials will be more quickly adopted generally, and progress in the development of still better methods and materials will be accelerated. In these surveys the bureau is acting in cooperation with the Asphalt Association, representing practically the entire road-asphalt industry of the United States.

MOTOR-TRUCK IMPACT INVESTIGATIONS

The investigation, mentioned in the last annual report, of the effect on motor-truck impact of the use of resilient or cushion wheels has been completed and a report issued. The study was undertaken with the thought that new developments in wheel equipment might be as effective in reducing the impact of trucks on pavements as are improvements in tire equipment. The general conclusion which resulted is that resilient wheels may reduce impact reactions and that the reductions may be negligible or important, depending upon the construction of the wheel and the tire equipment used. The cushioning properties of resilient wheels are much more pronounced with solid tires than with pneumatic tires. The data obtained are of particular interest to those who are con-

cerned with the evaluation of the road damage resulting from the use of various types of motor-vehicle equipment.

The major activity during the past years, in connection with the impact investigations, has been the thorough study of the accuracy of the determination of impact forces by the methods which have been developed by the bureau. This study has been made in cooperation with the Bureau of Standards and has involved extensive work in the calibration of the instruments used. The results themselves are extremely technical in nature and will be of little general interest, but they will establish the degree of accuracy of a vast amount of data relative to the subject of the impact of motor vehicles on roads and will eliminate all questions regarding the instruments used in future investigations.

CONCRETE INVESTIGATIONS

One of the first and most important steps preparatory to building a concrete road is the selection of the materials of which the concrete is to be made and the determination of the proportions which must be used in order to produce concrete of the desired quality Pavement concrete differs from other manufactured products only in that it is manufactured at the place of use rather than in a mill or factory. A knowledge of the effect on its quality of variations in the amount and character of the constituent materials is as important to the highway engineer as is the accurate control of furnace operation to the steel manufacturer.

Until quite recently it has been commonly assumed that so long as the mineral aggregates were sound and reasonably hard the particular kind or character of aggregate employed would have little, if any, effect on the strength of the concrete. In this way such proportions as 1:2:4, 1:3:6, etc., indicating proportions by volume of cement, sand, and coarse aggregate, respectively, came to be rather generally accepted as indicating concrete of a definite class or quality. However, it is becoming more and more apparent, as the results of additional research become available, that the strength of concrete may be affected appreciably by the kind of coarse aggregate used. It has become evident that if concrete mixtures are to be designed intelligently consideration must be given to factors other than simple volumetric proportions.

One of the major investigations of concrete completed during the past year was an extensive series of tests to determine the effect of the kind or type of coarse aggregate on the strength of concrete. Seventeen different aggregates were used, of which 7 were crushed stone, 7 were gravel, and 3 were blast-furnace slag. The crushed stone ranged from a very hard, tough, trap rock to a soft limestone, while the gravels included the glacial types of the Northern States, sedimentary or limestone gravels, and those of the quartz varieties. Slags of three different degrees of density were used. Over 2,000 concrete specimens were made and tested in this investigation.

The results of the study showed that, other things being equal, a change in the type or kind of coarse aggregate used in the mixture may cause a very considerable change in the transverse strength of the concrete, in some cases as much as 30 per cent.

One of the aggregates chosen for study, a quartz gravel, when used in concrete of a 1:1.6:3 mix, gave an average modulus of rupture of 535 pounds per square inch, while a limestone gravel in concrete of the same proportions gave an average modulus of 650 pounds per square inch. In concrete of a 1:2:4½ mix the same materials gave average modulii of 420 and 520 pounds per square inch, respectively. The significant point of this comparison is the fact that the limestone gravel in the lean mix (1:2:4½), which required only 5 sacks of cement per cubic yard of concrete, produced concrete of practically the same strength as the concrete of the richer mix (1:1.6:3) containing the quartz gravel and requiring 6.6 bags of cement per cubic yard.

On the assumption that it is desired to build a concrete pavement of a certain definite strength, and that these two aggregates are both available and sell at approximately the same price, the use of the aggregate producing the higher strength would result in a saving, under normal price conditions, of at least $1.500 per mile of 18-foot roadway. This example illustrates the economic advantage of a definite knowledge of the factors which affect the quality of concrete and the ra-

tional application of this knowledge in the design of concrete mixtures.

The maximum amount of coarse aggregate which may be used in concrete mixtures without sacrifice of quality is another problem of importance. Other things being equal, the greater the proportion of solid stone or gravel in a unit volume of concrete, the greater is the durability of the product from the standpoint of resistance to weathering action. Also, as a general rule, an increase in the amount of coarse aggregate reduces the cost of the concrete since there is a relatively smaller use of cement, the most expensive element of concrete.

On account of the extra labor involved in the hand finishing of concrete containing a high percentage of coarse aggregate, the use in paving work of mixtures containing an excess of mortar has come into general favor even though such mixtures may not be the most economical from the standpoint of the cost of materials and even may be somewhat deficient in quality. The great advances which have been made in the development of mechanical equipment for concrete-pavement construction and the general adoption of this equipment, with the consequent reduction of hand labor, has made practicable the use of the harsher concretes which are produced when appreciable increases are made in the proportion of coarse aggregate. Thus, it becomes necessary to know the effect of increases in the amount of coarse aggregate on that most important quality, strength.

For the purpose of studying this problem an investigation has been started which involves the construction of a concrete pavement 9 feet in width and somewhat over a half mile in length. In the test sections of which this pavement will be composed various proportions of gravel, crushed stone, and blast-furnace slag are being used. In order that the results obtained may be representative of those which might be secured in regular paving work, the construction is being carried on with mechanical equipment of the latest design, including weighing batcher-plants for proportioning the materials, a full-size paving mixer, and finishing machines.

The pavement will not be subjected to traffic but will be cut into beams the flexural strength of which will be determined by testing. The investigation includes the placing of more than 600 cubic yards of concrete and the testing of about 5,000 specimens.

Previous work by the State Highway Commission of North Carolina has indicated that the amount of coarse aggregate commonly used in pavement concrete can be considerably increased without any appreciable reduction in strength. If these findings are corroborated by the present investigation a considerable economic advantage will result.

HIGHWAY-BRIDGE INVESTIGATION

In the construction program of the Port of New York Authority there are included a number of long-span bridges, the most notable of which is the Hudson River Bridge which will have a main span of 3,500 feet, the longest suspension bridge in the world at this time. Possible improvements in the quality of concrete used in the floor slabs of bridges and possible advantages to be gained by the use of lightweight concrete in the floors of long-span bridges are matters of general importance in the highway field and of immediate importance to the Port of New York Authority. The common interest in these problems led to a cooperative arrangement between the bureau and the Port of New York Authority under which an extensive series of tests is being conducted at the Arlington Experiment Farm.

The program involves the construction, with materials and methods such as might be used in the construction of bridge floors, of 22 concrete slabs, each 6 feet wide and 22 feet long. Different aggregates have been used, including one of light weight which resulted in a concrete weighing only about two-thirds as much as the ordinary product, and different vibratory methods were employed in placing the concrete for the purpose of increasing its density and thereby improving its quality. The large slabs were subsequently cut up into smaller pieces of sizes suitable for testing. The program includes tests to determine the strength of plain and reinforced slabs, the bond strength of embedded steel, and the density, durability, and elastic properties of the concrete. The testing work is approaching completion and it is indicated by the data thus far available that information of considerable value to highway engineers will

be obtained. It is anticipated that the results will be reported during the next fiscal year.

DIVISION OF AGRICULTURAL ENGINEERING

IRRIGATION INVESTIGATIONS

DUTY-OF-WATER STUDIES

A report covering the irrigation requirements of the Columbia River Basin has been submitted for publication, this being the fourth of a series of five publications dealing with the requirements of various large areas in the West. Studies of irrigation-water requirements in San Diego County, Calif., and of the economic duty of water in the Sacramento Valley, Calif., conducted in cooperation with the University of California, have been completed and reports will be published by the cooperating agency.

The cooperative investigation of the penetration and storage of rain falling upon valley floors in the Santa Ana River area in California is being continued. Soil samples have been taken regularly during selected periods from the "consumptive use of water" plots, which included citrus, walnuts, peaches, and brush, and laboratory determinations have been made of the moisture content. The experiments at Devil Canyon tunnels on rainfall penetration are being continued, but the measurements on rate of evaporation and transpiration losses from the river bed under field conditions were temporarily discontinued because the scant rainfall during the rainy season resulted in the drying up of Temescal Creek, the site of the study. During the year the Army air service in the territory made an airplane survey of the moist area, without cost to the Bureau of Public Roads. Near Santa Ana and San Bernardino daily evaporation and transpiration losses were measured and additional tanks installed in order to determine the effect, if any, of an oil film on the rate of evaporation from a free water surface.

Investigations to determine the consumptive use of water in the Sacramento-San Joaquin Delta have been carried on since 1924, under cooperative agreement with the State of California and the agricultural experiment station. The delta contains nearly a half-million acres approximately at sea level, and is traversed by a network of navigable channels. Even at low tide the water surface in the channels is higher than much of the land. About half the area has been reclaimed by the interposition of some 1,500 miles of levees. The interior of the region is mostly peat, 5 to 40 feet or more in depth. The outlying portions and strips along the natural channels are slightly higher and are currently classified as sedimentary. Water (usually in amounts greatly in excess of crop requirements) is drawn from the channels through culverts and siphons and by pumping. Drainage, consisting largely of excess admitted from the channels, is returned to them by pumping. The prevailing system of distribution is designed for subirrigation, but surface irrigation is practiced to some extent on sedimentary lands.

It is desirable that consumptive use of water be determined on large tracts bearing a variety of crops, on individual fields of single crops, and, as permitting the maximum of precision, on crop plants grown in soil tanks. The 23,000 acres of sedimentary land in the lower unit of reclamation district No. 999 present exceptionally favorable conditions for determining the use on a large tract. There is, however, a gravel stratum 30 feet and more below the ground surface, which connects with the water in the channels and gives rise to vertical seepage. On Medford Island, consisting of 1,200 acres of deep peat, the drainage withdrawal in the irrigation season was found to be almost equal to the amount of water admitted, indicating that almost enough water for the crops reached them by underground paths. The use of water on individual fields of single crops, on both peat and sedimentary lands, has been determined satisfactorily in some instances. The methods employed in growing crop plants in soil tanks are believed to duplicate almost completely the essentials of field conditions. By taking into account the factors which tend to make practical field irrigation relatively less efficient, the tank results may constitute a principal basis for the estimation of the proper share of the delta lands in the waters of the rivers. An additional pertinent use of the tanks is to determine the consumptive use by aquatic and other growths which present a material demand. Full-scale operations on sedimentary lands were suspended at the close of the season of 1928, but those on the peat lands are still in progress.

In connection with these investigations, a 60-inch steel siphon was rated

under conditions of full and partial vacuum, and a rod with electrical connections was devised for the precise observation of water levels in certain situations, as in tube wells, where the hook gage can not be used.

LOSS OF WATER BY EVAPORATION

The results of investigations during former seasons have been brought together in a report on evaporation from free-water surfaces, which will be submitted to authorities on the subject for review and criticism in the immediate future. Some studies are yet to be made on large reservoirs to check the formula derived as a result of former studies.

PUMPING FOR IRRIGATION

A bulletin on pumping for irrigation and drainage is in preparation. The bulletin will include a summary of methods and practices peculiar to certain representative districts in the West, a discussion of economic problems which limit the profitable utilization of pumping plants in irrigation practice, an outline of the procedure to be followed in determining whether or not a pumping venture may succeed, a description of the types of pumps and standard equipment and their uses, and a study of plant efficiency and power problems.

DESIGN, INVENTION, AND TESTING OF APPARATUS

The studies of design and behavior of various measuring devices and water-stage recording instruments have been continued. Some noteworthy progress has been made, especially in extending to very large dimensions the Venturi flume, developed by members of the Division of Agricultural Engineering. This has been adopted by the State engineers of two Western States as a standard device for the measurement of irrigation water where weirs and other calibration devices, because of topographic or other conditions, would be inaccurate. Studies have also been made of a new adjustable tube measuring device. Improvements have been made on the Hoff meter, and some new water-stage recording devices have been developed.

CONTROL OF GRAVEL AND SILT IN IRRIGATION CHANNELS AND RESERVOIRS

This investigation is now confined to the Texas field where, in cooperation with the State Board of Water Engineers, the silt-carrying capacity of several selected streams and rates of deposit in certain reservoirs are being studied. Daily water samples are taken during flood and normal water stages, and analyses are made of the silt content. A study of the movement of bed silt is also in progress. Due to the uncertainty of stream flow it is not possible to state at this time how long it will be necessary to continue these studies.

FLOW OF WATER IN DITCHES, PIPES, AND OTHER CONDUITS

The manuscript on the flow of water in riveted steel and analogous pipes has been submitted for publication. The study of the flow of water in flumes is being continued and will, in all probability, be presented in the form of a manuscript for publication during the coming fiscal year.

CUSTOMS, REGULATIONS, AND LAWS RELATING TO IRRIGATION

Studies begun during the fiscal year 1928 in cooperation with the Oregon Agricultural Experiment Station, involving the engineering, agricultural, and general economic status of various irrigation districts in Oregon, were continued at the invitation of the State Reclamation Commission. These districts, organized during the postwar period, received advances from the State to cover interest on their bonds for periods of one to five years, to enable the farms to be brought into profitable production before the usual payments for construction must begin. These advances originally were to be repaid after maturity of the bonds.

The purpose of the State's plan was not accomplished. Development was not speeded up; large portions of the lands are still untilled; and most of the districts have been unable to meet their obligations. Other elements of failure, such as faulty engineering, insufficient water, and mistakes of organization and management, have entered into the history of these districts, as they have elsewhere.

The studies involved 8 of the 14 districts assisted by the State. On the basis of the conditions disclosed a relief measure was enacted by the legislative assembly of 1929, by which the districts may be relieved of their obligations to the State in case the bondholders agree to readjust their claims on bases ascertained to be economically justifiable. Negotiations are now in progress between most of the

districts and the holders of their bonds to effect such settlements. At a previous session of the legislature a law was enacted, at the suggestion of the Division of Agricultural Engineering, which provides for the assessment of bond-principal obligations on a plan of individual rather than joint liability.

This investigation has involved a research into the causes of the distress of a group of districts that are representative of a great many such enterprises throughout the West. The lessons taught by the history of this group are to be discussed in a report for publication.

OTHER IRRIGATION ACTIVITIES

The studies of the reclamation of alkali land in cooperation with the Utah and Idaho experiment stations are being continued. The investigation naturally yields results very slowly. There is no hope of reaching any very definite conclusions as to the cost and feasibility of reclaiming alkali tracts during the coming fiscal year, but it is felt that progress has been made and that the study is well worth continuing.

A manuscript on the discharge of drains serving irrigated lands has been prepared during the fiscal year and will shortly be submitted for publication. Further studies of drainage methods, their efficiency, effectiveness, and cost are being carried on in New Mexico, Oregon, and Washington.

DRAINAGE INVESTIGATIONS

RUN-OFF MEASUREMENTS AND DITCH CAPACITIES

Continuing the studies of many preceding years to determine the necessary capacity of ditches and other works for land drainage, investigations were made relative to rates of run-off from 4 small hilly areas in Little River Drainage District in southeastern Missouri, from 10 areas in northeastern Indiana, and from 1 very small area in Iowa. Continuous records have been obtained of the flow in the channels draining these areas and of the rainfall upon each area, and careful descriptions of the size, shape, topography, soil, and vegetative covering of the areas have been prepared. Manuscript reports of run-off investigations in southern Illinois, in southeastern Arkansas, and in Bolivar and Washington Counties, Miss., have been completed.

Computations of the sizes of ditches that must be constructed to carry predetermined quantities of flow are based upon some formula that combines the various measurable hydraulic elements and an empirical resistance factor. Experiments to determine values of the roughness coefficient in the Kutter-Chezy formula for velocity of flow were made in connection with the run-off measurements in northeastern Indiana. Accurate measurements of discharge, water slope, and size of stream were made in different channels, and compiled with detailed descriptions of the condition of the waterway with respect to soil, vegetation, and accumulation of débris. Similar experiments were made on a large floodway covered with growing timber in northeastern Arkansas. A report showing the results of such measurements made in prior years in eight States, with recommended values to be used for the Kutter roughness coefficient under different conditions, is now in press.

SOIL-EROSION INVESTIGATIONS

The studies of rates of run-off and erosion from experimental plots near Raleigh, N. C., in cooperation with the State experiment station, have been continued. The appropriation act for the fiscal year 1929 provided a special fund to be expended by the Department in studying soil erosion and its prevention. The fund was allotted among the Bureau of Public Roads, the Bureau of Chemistry and Soils, and the Forest Service. In January, 1929, experiments were begun on a 160-acre farm near Guthrie, Okla., made available by the Guthrie Chamber of Commerce. Since then, 75 acres of that farm have been terraced with 7 miles of terraces; 63 dams of different types have been built and 1,800 feet of gullies have been filled with brush to check erosion; 15 acres have been partly cleared and grubbed; 60 acres have been planted in cotton, and 41 acres in various other crops. Additional experiments were begun in April, 1929, on a 140-acre farm near Temple, Tex., in cooperation with the State Agricultural Experiment Station. A survey and map of the farm have been made, and other preliminary work done. About 15 acres have been terraced, and planted in cotton.

The purpose of the soil-erosion investigations, which have been conducted, with slight interruption, since 1915, is to determine the most practicable means of preventing or reducing erosion of agricultural lands, by ter-

racing, by underdrainage, or by cultural methods.

Measurements are made and detailed data are collected relative to (1) the rate of movement of soil down different land slopes; (2) the design of terraces and terrace systems according to differences in soil types, land slopes, and rainfall distribution; (3) the rates of run-off and of soil erosion from terraced and unterraced fields; (4) the best methods of constructing terraces with different kinds of implements; (5) economical methods of maintaining the terraces in effective operation; (6) the effectiveness of terraces for conserving rainfall, by increasing the amount absorbed by the soil; (7) satisfactory methods of operating farm implements and machinery in terraced fields; (8) the proper design and construction of different types of soil-saving dams for checking erosion and reclaiming gullies; and (9) the effectiveness of different cover crops in reducing or preventing erosion, on terraced and on unterraced lands. Study of the effectiveness of deep plowing, subsoiling, and underdrainage in checking soil erosion is contemplated. On the farm near Temple studies of level, as well as of sloping terraces, will be made and crop yields on terraced and unterraced lands will be compared.

FLOW AROUND BRIDGE PIERS AND CHANNEL BENDS

Continuing studies, begun in 1928, on the obstruction of bridge piers to flow of water, approximately 980 experiments were made at the hydraulic laboratory of the University of Iowa. Twin piers were used, each 14 inches wide, in a testing canal 10 feet wide, with 7 combinations of nose and tail shapes. The effects of the piers in increasing the depth of water were measured for different depths and velocities of flow. The results were consistent with those obtained in 1928 and, like the latter, gave coefficients for various bridge-pier formulas that differed somewhat from those obtained by other experimenters. In regard to least deviation from the test data, the formulæ arranged themselves in the following order: Nagler, D'Aubuisson, Rehbock, and Weisbach.

It is believed, as a result of the experiments, that the erosion which occurs around the base of the up-stream end of piers is due to the downward component of the velocity of the water. For use in measuring these velocities, a self-contained instrument that combines a Pitot tube for measuring the velocity and a current-direction indicator for registering both horizontal and vertical angles has been designed, and some work on the manufacture of it has been done.

A report upon the effect of variations in direction and rapid changes in speed of flow upon the registration of current meters with rod suspension has been completed, giving the results of a large number of experiments on 11 types of current meters tested in very turbulent flow at the hydraulic laboratory of the University of Iowa.

A model of Des Moines River Valley at Ottumwa, Iowa, was constructed in the hydraulic laboratory, and tests were made to determine the probable effect of digging cut-offs across two large bends in the channel. The observed results on the model checked closely the results computed for the actual river channel. Construction and observation of the river cut-offs will yield data that are expected to be of material value in determining the general dependability of results obtained from models.

OPERATION AND MAINTENANCE OF PUMPING PLANTS

Something like 500,000 acres of bottom land along Illinois River and along the Mississippi between St. Louis and Savanna, Ill., are organized in districts that have constructed levees for flood protection and pumping plants for drainage, at an average cost exceeding $40 per acre. The annual operating costs for the pumping plants alone, including fixed charges, average probably $1.50 per acre. Most of these districts are in financial difficulty, and many land owners have lost their farms. Much of the pumping equipment is inadequate to give proper drainage, and is inefficiently operated.

For the purpose of analyzing the methods and costs of operating and maintaining these plants, records and tests on 15 plants have been obtained in the last few years. During the past year, as previously, record was made of rainfall, run-off pumped, frequency and duration of pumping, lift of water, amount of fuel or power used, and costs. Further tests of pump and overall efficiencies were made. The results emphasized certain conclusions previously stated, that efficiency is greatly increased and power cost reduced by adjusting the speed of the pumps to the lift of the water and by keeping the pumps, piping, and screens free of trash. Further, it was apparent,

cleaning of ditches leading to the pumps would give much more effective drainage in some districts. Third and fourth progress reports on this investigation have been prepared, giving the records and conditions of pumping at the districts under investigation during 1926 and 1927.

USE OF OPEN DITCHES AND TILE DRAINS

A manuscript for a Farmers' Bulletin on farm drainage has been prepared and is now being printed.

A report upon the economical use of large tile in land drainage has been prepared. This report compares the total costs of drainage by means of open ditches and the larger sizes of tile, including costs of maintenance as well as construction.

DRAIN-TILE MATERIALS

The experiments and tests of concrete draintile and concrete cylinders in alkaline soils and waters have been continued, in cooperation with the University of Minnesota and the Minnesota Department of Drainage and Waters as before. The investigation has been broadened to include (1) studies of the resistance of concrete and of clay tile to acids found in peat, muck, and some other soil types, and (2) studies to develop, if possible, some reliable tests of the resistance of tile to frost action that can be made more readily than tests now prescribed by the American Society for Testing Materials.

EFFECT OF DRAINAGE ON FOREST GROWTH

A study of the reaction of swamp forests to drainage was made in northern Minnesota, in cooperation with the Forest Service and several State agencies. The report, published by the State commissioner of drainage and waters, shows an average increase in growth, due to drainage, of about one-fourth cord per year on the test plots. The forest types were black spruce, tamarack, and cedar.

FARM-LAND DEVELOPMENT

POISONING TREES AND STUMPS

Clearing land of trees and stumps by any means that the individual farm owner can employ is at best a slow and laborious process. Not the least part of the work is the repeated cutting of the sprouts that spring from the green stumps. Poisons applied to cuts in the trees have sometimes been effective in killing both tree and stump. Therefore investigation has been undertaken to determine the value of such treatment for different kinds of trees. Various poisonous compounds have been used at different seasons of the year, and the compounds have been injected into the trees and stumps by various methods. The experiments are being made in six Central and Eastern States. Examinations are made at intervals to note the rapidity with which the trees and the stumps die and decay. Some varieties of trees die quickly after being poisoned; but, thus far, pines and some other varieties seem to be affected very little.

CLEARING LAND OF BRUSH AND STONE

The removal of brush is a considerable part of the work of clearing farm lands in the Lake States. Investigation has been begun, in cooperation with the University of Minnesota, to determine the cost of clearing brush land by plowing, by pulling, by burning, and by cutting and poisoning. Tests are being made to determine whether the intense heat under burning brush piles injures the soil, and may be the cause of the sterile spots that are found in large numbers in some localities.

In certain parts of Minnesota great numbers of stones are scattered over the ground. It has been suggested that they are being brought to the surface continually by frost action, a condition which would require that those lands must be cleared of stone not once only, but periodically, if they are to be kept suited for cropping. Data are being collected to ascertain whether there is truth in the suggestion.

MECHANICAL FARM EQUIPMENT

CORN-BORER CONTROL

The development of mechanical devices for combating the European corn borer, and the testing of different kinds of farm machines in control work, have continued along the lines established in the preceding year. Over 60 plows, variously equipped, were tested for cornstalk coverage on several different soil types. Studies of plow-body shapes and beam clearances were included. A stationary low-cutting knife to harvest the whole stalk has been devised, with the appurtenant parts necessary for attaching and operating it on four prominent makes of corn binders. A stubble-slit-

ter attachment for a standard corn binder has been devised and is being tested. A simple sled-type 2-row stalk shaver has been developed, two of which with a 3-horse hitch may be used to cut four rows at a time. Tests of new and used husker shredders were made to determine the influence of various adjustments on the effectiveness of the machines in killing borers in infected stalks. Studies of equipment for heat treating the larvæ in the field were continued, but not completed. Tests have been made of poling and raking implements for collecting crop débris, and of the effectiveness of different baling pressures for destroying the borers, but additional study of these and other kinds of equipment are in progress.

FERTILIZER DISTRIBUTORS

Supplementing the laboratory investigations of the preceding year, field tests of 24 fertilizer distributors have been made to study the effect of different kinds, amounts, and placements of fertilizer on the germination, growth, and yield of cotton. The practicability of machines that both plant the seed and apply the fertilizer will be compared with that of separate machines for the two operations. Planting and fertilizing were done in the spring of 1929; yields will be measured in the fall. The tests were made in cooperation with the Bureau of Chemistry and Soils, the joint committee on fertilizer application, and Clemson Agricultural College and Experiment Station, S. C.

COTTON-DRYING EQUIPMENT

The cotton-drying unit constructed and tested in 1927 was tested again in 1928 with favorable results, and a manuscript has been prepared for a bulletin describing the construction and operation of this equipment. Some growers who observed the operation of the test unit are already installing like driers for treating their 1929 crop.

SUGAR-BEET MACHINERY

A preliminary study has been made of the machinery used and labor required for producing sugar beets, from preparation of the land for planting to delivery of the beets to the factory or railroad. Analysis of the data collected indicates that mechanical equipment can be utilized to perform a large part of the work now done by hand, and thus appreciably reduce the cost of production.

ARTIFICIAL DRYING OF HAY AND SMALL GRAIN

In the humid region, unfavorable weather conditions at hay-making time often result in improper curing of the hay, and sometimes practically total loss of the crop. Wherever hay is cured by drying in the field, even under favorable conditions, a considerable portion of the leaves, the most nutritious part of the plant, is lost by shattering in handling. Therefore, investigation of the practicability of artificial drying has been undertaken, in cooperation with the Bureau of Plant Industry and the Nebraska Agricultural Experiment Station. The purpose of the experiments in the fiscal year 1929 has been to discover the principles involved in removing water from hay. In the experimental apparatus, small quantities of green hay were reduced to a desirable moisture content in one and one-half to three hours, by evaporating about two-thirds the weight of the green hay. The cured product graded No. 1 extra leafy, valued then at $8 to $10 per ton higher than the ordinary grade. Development of drying equipment for general farm use has not yet been begun.

Since an excessive moisture content in grain is likely to cause damage in storage, experiments were begun to determine the practicability of artificial drying of wheat. In cooperation with the Bureau of Agricultural Economics, a small experimental drying outfit was set up and operated in 1928 at Fargo, N. Dak., to study the time and heat requirements for drying and to determine the effect of artificial drying upon the grain. It was found that the use of temperatures up to 160° F., the highest used, had no material effect upon germination or upon the milling and baking qualities. Further experimentation is required.

FARM STRUCTURES

DAIRY BARNS IN SOUTHEASTERN PENNSYLVANIA

Many old barns still structurally sound are not suited to production of milk in accordance with requirements set up by public health authorities in many of the larger cities. Particularly is this true of the bank type of barn very common in southeastern

Pennsylvania, owing to inadequate lighting and difficulties of ventilation. For the purpose of determining what changes are practicable in improving existing barns, or in replacing barns that have been destroyed by fire or other cause, in order that the milk produced may be marketed in the cities, an investigation of the dairy barns in southeastern Pennsylvania was made, in cooperation with the Interstate Milk Producers' Association of Philadelphia. The report of conditions found, with general recommendations, has been prepared.

HEATING OF GREENHOUSES

The operation of even a small commercial greenhouse is a matter of considerable expense, and the cost of heating is one of the principal items. Control of temperature is also one of the important factors in successful operation. Because there is little information available concerning this subject applicable to small greenhouses of the commercial type, a study of selected structures of this kind has been undertaken to determine, for such structures, the heating requirements as affected by climatic conditions, the best types of heating systems, the advantageous kinds of fuel and methods of firing, the effective and economical means of temperature regulation, and the proper basis of proportioning the heating system to the size and construction of the house. The investigation is not yet complete.

Laboratory experiments have been undertaken to determine the effect upon temperature distribution in cold-storage rooms, of different locations and arrangements of the cooling pipes, of different areas of the cooling surface, and of different temperatures of the refrigerant; and also to determine to what extent humidity can be controlled by proper arrangement, location, area, and temperature of the cooling surfaces. Collection of the data is still in progress.

SERVICE WORK

A considerable part of the time of the staff of the structures section during the past year has been required for designing barns, a greenhouse, a machine shop, an abbatoir, and other buildings, and preparing specifications for buildings and equipment for various other bureaus of the Department of Agriculture.

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No Report published

for 1929

UNITED STATES DEPARTMENT OF AGRICULTURE,
WEATHER BUREAU,
Washington, D.C.

September 3, 1929

SIR:

I have the honor to submit herewith a report of the operations of the Weather Bureau during the fiscal year ended June 30, 1929.

Respectfully,

C. F. Marvin

Chief of Bureau.

Hon. Arthur M. Hyde,
Secretary of Agriculture.

RELEASE OCT. 16

To secure a satisfactory widespread distribution of sea reports, it is obvious many ships must be enlisted since many are constantly in port.

FROST AND FIRE - WEATHER WARNINGS

Among the older and well-established services of the bureau must be mentioned that of frost warnings in aid of the citrus and horticultural interests. Great economic savings by the artificial heating of orchards have now been completely demonstrated to be possible, and plans for extending this activity to certain new localities during the next season are being made.

A similar statement can be made concerning the economic value of the fire-weather warning service of the bureau. This has been particularly well organized over the northern and western portions of the States and awaits funds to extend equal service to the south and east.

Following the national awakening to the economic challange involved in the great floods of the Mississippi River, and the inauguration of great flood relief and protection work, the Weather Bureau, which is charged by law with the issue of flood warnings and the gaging and reporting of rivers, is planning a careful survey of its river and flood work and the refinement, as far as possible, of its forecasting system.

Conforming to the abridged plan recently followed, this report will briefly discuss only a few leading features in which the activities of the bureau made more striking progress or expansion.

AERONAUTICAL METEOROLOGY

The public is well acquainted with the rapid and wide-spread practical use of aircraft for mail, freight, and passenger transportation, and even private flying, including military training and manoeuvers. The law charges the Weather Bureau with giving weather information and forecasts to pilots through cooperation with the Department of Commerce.

It is highly important that all aviation interests understand just how the air commerce act works out in practice. A great many cities, large and small, have already set about developing what we may now call local airports, either privately owned and operated, or under municipal control. New cities are being added to the lists almost daily. These localities need and expect adequate weather service, and it is the policy of the bureau to supply the same as far as possible. Its appropriations, however, are always made to put into operation a definite program of work laid out several months in advance and for airways and airports designated by the Department of Commerce as official. Manifestly, the bureau has no special funds that can be diverted to outside activities. The case is further complicated by the utilization in the same metropolitan area of two or more airports which, in the meteorological sense, are closely contiguous. One of these is often the official airport, and sometimes questions of rivalry and competition are factors with which the Weather Bureau must deal in its desire to render its service equally and impartially to all.

Its basic policy is to station at each official airport a sufficient staff of trained personnel to give continuous weather advices to all pilots during the entire 24 hours of each day if the flying schedules so require, and previous plans and appropriations have provided therefor.

In those cases where extra service, especially at contiguous unoffi-cial airports and those in cities at which regular Weather Bureau stations are not maintained, is desired, it is obviously impossible, without funds, to supply any service except that issued through the regular public channels of the press and scheduled broadcasts.

The bureau is always glad, however, to give consideration to special situations, and occasionally some arrangements can be made to meet peculiar situations. The cooperation of the transport and aviation interests is earnestly solicited by the bureau to realize as full and complete utilization of those official airports and the facilities as they are maintained by the Government, rather than to plan for great multiplication of places where nearly identical information is desired. Both night and day flying are now becoming more general, and the need for 24-hour service greatly increases the number of trained personnel required, as well as the costs. From the very nature of the situation it is difficult to render service as rapidly and widely as aviation itself advances.

It is gratifying to mention that substantial increases in appropriations were made by the last Congress to put into effect plans for an extended program of night and day service over the transcontinental airway from New York to San Francisco and Los Angeles. Within a zone of nearly 300 miles transverse width, weather observations will be made at intervals of every three hours. Carrying out the details of this plan belongs to the next fiscal year and will then be reported.

WEATHER REPORTS AT SEA

Mention was made in the previous annual report of the concerted international movement to add a systematic network of ocean stations by means of selected ships traversing the high seas. The principal maritime nations are obligated under this informal understanding to enlist selected ships, each of its own registry, to make at least two set observations daily while at sea and report to designated coast stations by radio. Such reports are added to the lists of stations included in the daily intercontinental and international exchanges of weather reports, thus aiding to fill in to a certain extent the wide gaps which have heretofore prevailed in weather maps over ocean expanses.

Approximately 50 ships are now making daily reports when actually at sea on the North Atlantic Ocean, alone. A lesser number are cooperating on the Pacific. These do not include a special group of coastwise ships and others traversing the Gulf of Mexico and Caribbean Sea, which report only during the hurricane season from June to November.

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